Sources of Propane Consumed in California

Energy Systems Division

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Prepared for the Western Propane Gas Association

September 2020

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ABBREVIATIONS

Argonne National Laboratory (ANL)

Barrel (bbl)

California Air Resources Board (CARB)

California Energy Commission (CEC)

Carbon Dioxide-Equivalent (CO₂e)

Energy Information Administration (EIA)

Gram (g)

Greenhouse Gas (GHG)

Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET)

Hydraulic Grade Line (HGL)

International Trade Commission (ITC)

Liquified Petroleum Gas (LPG)

Low Carbon Fuel Standard (LCFS)

Megajoule (MJ)

Natural Gas Liquids (NGLs)

Organization of the Petroleum Exporting Countries (OPEC)

Petroleum Administration for Defense Districts (PADD)

Petroleum Refinery Life Cycle Inventory Model (PRELIM)

Rest of World (ROW)

Steam Assisted Gravity Drainage (SAGD)

Synthetic Crude Oil (SCO)

Thousand Barrel (kbbbl)

Thousand gallons (kgal)

Well to Wheels (WTW)

United States (U.S.)

United States Environmental Protection Agency (U.S. EPA)

EXECUTIVE SUMMARY

Project Scope

The objective of this study is to specify the sources of propane consumed in California. It answers the questions, where does the propane used in California come from and how was it produced? The results of this study provide comprehensive, transparent, and verifiable estimates, based on the 2018 market. The information provided in this report is suitable for use to assess the life cycle carbon intensity of propane used as a transportation fuel in California. As the 2009 Low Carbon Fuel Standard (LCFS) aims to reduce California's greenhouse gas (GHG) emissions and other smog-forming and toxic air pollutants, the appropriate designation of carbon intensity for propane as a transportation fuel is important for evaluating propane's potential to contribute to GHG goals and understandings in the context of various actions. This study focuses on estimating the shares of total propane consumed in the state of California produced from petroleum refineries, natural gas plants, and bituminous sands sources inside California and elsewhere.

Results

An estimated 590 million gallons of propane were consumed in California in 2018, of which, 59.5% originated from refinery production and 40.5% originated from natural gas plants. The majority of this was sourced from refinery production in California, 334 million gallons. Most of the propane imported to California for consumption was sourced from natural gas plants, 113 million gallons, with over half of the imported volume sourced from Canada. The volume sourced from bituminous sand upgrader and fractionator operations was negligible. Details from this analysis are presented in the table below which provides an overview of the propane flows estimated in this study by region and production method. The shares and volumes presented here represent a snapshot for 2018. A significant increase in propane demand, such as could be caused by increased use of propane as a transportation fuel in the state, would affect California's propane production, imports, and exports. The method and data sources used for the estimates provided in this report also provide the framework which could be used for future updates.

Key Method Considerations

The values presented here are based on a two-step approach where the first step was to determine the flows of propane into and out of California from different regions and the second step was to estimate the propane production methods in each region. A volume balance approach is used as the primary method for tracking the volume of propane in and out of California¹ as propane production and import volumes are available by Petroleum Administration of Defense District (PADD) from EIA and neither inter-PADD propane transfers nor state-specific non-prime supplier consumption are available from a public data source.

The volume balance performed for this study covered PADD 5 (the West Coast), which includes Arizona, California, Nevada, Oregon, and Washington.² The volume balance used all available public datasets to determine propane production, imports, exports, and consumption. Volumes unaccounted for by these datasets were estimated using the resulting volume balance by assuming market equilibrium.

Consumption within each state in PADD 5 was estimated based on known import, export, and production volumes and this amount was used to develop the volume balance. EIA only tracks consumption at the state level by prime supplier sales. The volume balance approach provides the basis to correct for additional propane consumed in-states where propane is transferred to California. To determine the

¹ California production data was obtained from the Energy Commissioner, at request.

² This analysis estimates all propane produced in Alaskan and Hawaiian refineries were consumed in-state in 2018; furthermore, there is no viable production of propane from the gas processing facilities in Alaska or Hawaii.

California propane sources and trade in 2018.

volume of propane consumed in California, the volume balance approach is again used where it was estimated all imported volumes not specifically flagged for re-export were consumed, and the remaining consumption was produced in-state. The California Energy Commission (CEC) provided the total volume of propane imported and exported from California in 2018; this volume data set along with commodity tracking from the Canada Energy Regulator (CER) and the International Trade Commission (ITC) which tracks port of entry and final destination was used to determine where propane originated from and where it was ultimately consumed. For example, the CER tracks propane leaving Canada and entering each state within the U.S. Imported propane from Canada to California – marked for California – is assumed to be consumed in California. When no further data were available, import volumes were assumed to be consumed in California without pass-through (i.e., no propane imported to California was directly sold and exported).

In most cases, the production method for each propane source region was applied to the volume of propane transferred to California. In other words, the shares of propane sourced from natural gas and refineries for each production region was assigned to California imports based on their contribution to the total volume flows into California to determine the production method for propane consumed in-state. For volumes imported into California from PADD 4, Washington State, Canada, and the rest of the world (Argentina, Chile, Norway, Peru, South Korea, and Trinidad and Tobago), the volumes sourced from petroleum refineries and natural gas plants reflect the either production ratio for the region or, in cases where the sources specific to the amounts exported to California could be determined, the sources specific to the volumes transferred to California.

Sources of propane consumed in California. Values for 2018 shown in thousand gallons.

<i>Parameter</i>	<i>Total Volume</i>	<i>Refinery</i>	<i>Natural Gas Plant</i>
Production, in state	566,496	411,936	154,560
Imports	129,653	16,546	113,106
PADD 2	0	0	0
PADD 4	10,795	574	10,221
other PADD 5 states	9,166	9,166	0
Canada	78,738	2,791	75,946
ROW			
Argentina	2,940	176	2,764
Chile	2,394	2,394	0
Korea, South	2,352	888	1,464
Norway	4,662	55	4,607
Peru	2,352	71	2,281
Trinidad and Tobago	16,254	431	15,823
Exports	107,367	78,074	29,294
other PADDs	0	0	0
other PADD 5 states	772	562	211
Canada	0	0	0
Mexico	106,247	77,259	28,988
ROW	348	253	95
Consumption	588,780	350,407	238,373
<i>Imports + (Production - Exports)</i>			
Imports	129,653	16,546	113,107
Produced in-state	459,128	333,862	125,266
Propane Sources	100%	59.5%	40.5%

1. INTRODUCTION

1.1. Overview

The objective of this study is to specify the sources of propane consumed in California. This objective is accomplished through developing a comprehensive inventory of the sources of propane used in the California market using publicly-available data sources and resolving data on propane production by, imports to, and exports from other states in PADD 5, other PADDs, and other countries. The source of these propane volumes were then estimated based on the shares of propane from petroleum refineries, natural gas plants, and bituminous sands operations in each region. The results presented here are intended to support life cycle analysis to quantify the well-to-wheel (WTW) carbon intensity of propane used as a transportation fuel in California. The approach serves as an example of how similar estimates could be developed for other U.S. states. The form of the results presented here is suitable for implementation in the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to create state-specific carbon intensity estimates for propane used as a transportation fuel in California.

The remainder of Section 1 provides background information on propane production and distribution within, and outside of California. Section 2 presents the propane volume balance analysis, which quantifies the 2018 volume of propane produced in, exported from, consumed in, and imported into California. The balance also identifies the geographic location of the source of imported and the location to which propane is exported. Section 3 describes how the propane volume balance was used to derive an estimated percentage split of production by refineries, natural gas plants, and bituminous sand upgrader and fractionator operations for the propane consumed in California, which led to study results presented in Section 4. Data quality and bounding analysis are explained in Section 5 and study conclusions are presented in Section 6.

1.2. Background and Propane System Description

Propane (C_3H_8) is produced as a minor product of natural gas production, crude oil refining, and bituminous sands upgrader and fractionator operations. It is the main component of LPG, along with butane (C_4H_{10}), propylene (C_3H_6), and very small amounts of organic chemicals with two, three or four carbon atoms. The term “propane” is sometimes used synonymously with the term “LPG” (an abbreviation for liquid petroleum gas). In GREET 2019 model, propane derived from petroleum and natural gas pathways are separately modeled for each feedstock.³ While prior versions of GREET grouped together refinery-derived propane with butane and propylene and presented a pathway for LPG, these individual components were disaggregated in GREET 2019 to provide results specific to propane (and the other components).

The production methods for propane result in significantly different upstream carbon intensities. While in some cases, the production ratio for propane consumed in a specific location has been used to estimate the carbon intensity for propane in that location, significant volumes of propane are traded across regions and the sources of propane can vary significantly across regions. For example, while across the U.S., approximately 70% of LPG originates from natural gas production and 30% from crude oil refining, in California, approximately 70% of the propane originates from crude oil refining while 30% is from

³ U.S. Department of Energy, Alternative Fuels Data Center, “Propane Fuel Basics” website, https://afdc.energy.gov/fuels/propane_basics.html.

natural gas production. Significant transfers between states, as well as international imports and exports complicate this situation.⁴ To account for differences in the sources of propane across regions, the mix of sources for the propane consumed in California can be specified based on balance of propane produced in California and the volumes imported to and exported from the state.

Crude oil refineries produce a range of products including refined fuels, liquid refinery gases including ethane, propane, and butane, various combinations of these (i.e., LPG), as well as numerous co-products like residual oil, petroleum coke, lubricants, sulfur, waxes, and asphalt. Most commonly, refinery operations primarily focus on the production of gasoline and diesel, and as a result, propane is an incidental co-product.

Natural gas is produced by natural gas wells, crude oil wells, and associated gas wells from hydraulic fracturing as well as conventional gas recovery methods. GHG emissions from natural gas production occur during well operation, separation, and through fugitive emissions.⁵ Natural gas is comprised mainly of methane, with varying lesser quantities of light hydrocarbons and inert gases. During natural gas processing, propane is produced from recovered liquid components, termed natural gas liquids (NGLs), which also include ethane, methane, propane, and butane, as well as heavier hydrocarbons.⁶ Transportation of natural gas requires pressurized pipelines or liquefaction equipment.

Oil from bituminous sands, or oil sand, is a naturally occurring mixture of sand, clay or other minerals, water, and bitumen.⁷ Bitumen can be extracted using two methods, namely open pit mining and in-situ production. The choice of method depends on how deep the deposits are located beneath the Earth's surface. While most bitumen is currently produced via open pit mining, approximately 80 percent of oil sands reserves are only recoverable via in-situ production.⁸ Steam Assisted Gravity Drainage (SAGD), the most widely used in-situ recovery method, entails drilling two horizontal wells through the oil sands deposit, with one slightly higher than the other. Steam is continuously injected into the top well, which increases the temperature and causes the bitumen to become more fluid and flow into the lower well, from which it is pumped to the surface. Open pit mining is similar to traditional mineral mining operations and is typically utilized when oil sands deposits are less than 75 meters (246 feet) underground.⁹

⁴ ANL, 2019 GREET Model.

⁵ Unnasch, S. and Goyal, L. Life Cycle Associates, "Life Cycle Analysis of LPG Transportation Fuels under the Californian LCFS," LCA.8103.177.2017, October 24, 2017.

⁶ U.S. Department of Energy, Alternative Fuels Data Center, "Propane Production and Distribution" website, https://afdc.energy.gov/fuels/propane_production.html.

⁷ Natural Resources Canada. "What are the oil sands?" Website, last updated February 28, 2020, available at: <https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/clean-fossil-fuels/crude-oil/what-are-oil-sands/18089>.

⁸ Natural Resources Canada. "Oil Sands Extraction and Processing" Website, last updated February 19, 2016, <https://www.nrcan.gc.ca/energy/energy-sources-distribution/crude-oil/oil-sands-extraction-and-processing/18094>.

⁹ Natural Resources Canada. "Oil Sands Extraction and Processing" Website, last updated February 19, 2016, <https://www.nrcan.gc.ca/energy/energy-sources-distribution/crude-oil/oil-sands-extraction-and-processing/18094>.

Figure 1 Propane distribution, simplified system diagram.

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Bitumen recovered from open pit mines or in-situ extraction is a very thick, viscous substance that must be upgraded or diluted prior to transport through pipelines so that it can be used as a feedstock in refineries. Upgrading transforms bitumen into synthetic crude oil (SCO) through processes that either add hydrogen or remove carbon. SCO can be refined and marketed as consumer products, such as gasoline and diesel. During the SCO refining process, LPG which is referred to as “off-gas” is evolved and subsequently separated as an incidental co-product, much like in conventional crude oil refining. Given its more energy intensive extraction process, fuel products produced from oil sands crude have a higher carbon intensity than conventional crudes.

The propane consumed in California is produced in-state at natural gas plants and crude oil refineries or imported from domestic transfers, Canada, and other countries around the world. As shown in Figure 1, propane is transported from its point of production to bulk distribution terminals through a distribution system of pipelines, railways, trucks, barges, and coastal tankers. From the terminals, propane marketers fill trucks that carry the propane to end users, including retail fuel sites.¹² For the purposes of analyzing petroleum product supply and movement, government analysts have divided the U.S. into five primary PADDs. Figure 2 shows the geographic locations of the U.S. PADDs, that divide the U.S. and its Territories.

¹⁰ Image credits left to right: oil rigs (2) – macrovector; refinery - tele52; gas plant – subjob; transport ship - tele52; railcar - Oleg Chepurin; propane truck - cs_durant; pipe – tvectoricons; spherical tank – macrovector; cylinder truck - tele52; fueling station - Kirill Cherezov; agriculture – stevanovicigor; industry – weenvector; petrochemical plant - Zhanna Millionnaya; retail cylinder – yupiramos; grill - Ozgur Coskun; house - Vadim Georgiev.

¹¹ Imagery Copyright 2020 TerraMetrics, Map Data Copyright 2020 Google United States.

¹² U.S. Department of Energy, Alternative Fuels Data Center, “Propane Production and Distribution” website, https://afdc.energy.gov/fuels/propane_production.html.

Hawaii is excluded from the system boundary of this analysis as the state does not have any natural gas plants and propane produced by refinery operations is consumed in-state.¹³ In 2018, the Tesoro Ewa Beach refinery in Oahu had a capacity of 93.5 thousand barrels per day (kbbbl/day) and produced LPG but did not specifically market propane. The Kapolei refinery, also on the island of Oahu, had a capacity of 94 kbbbl/day in 2018 and sold propane exclusively to the local market for direct consumption.¹⁴ Note as of 2019, the Kapolei refinery has ceased operations.¹⁵

In 2018, Alaska operated five small refineries: Marathon (68 kbbbl/day), PetroStar (22 kbbbl/day), BP Prudhoe Bay (10.5 kbbbl/day), ConocoPhillips Prudhoe Bay (15 kbbbl/day), and PetroStar Valdez (55 kbbbl/day).¹⁶ Based on the collective refining capacity and lack of trade documentation into the PADD 5 ports from Alaska, this analysis estimates all propane produced via the Alaska refineries was consumed in-state. The North Slope has the potential to isolate propane for sales, but a distribution pathway south has not proven to be economically attractive in spite of a number of studies. Therefore, no propane from the gas processing facilities in Alaska are assumed to provide product to California.

Figure 2 Petroleum Administration Defense Districts (PADDs) in the United States.

¹³ U.S. EIA. Source: https://www.eia.gov/dnav/ng/ng_prod_pp_a_EPG0_ygp_mmc_f_a.htm.

¹⁴ In late 2018, the Kapolei refinery purchased the Tesoro Ewa Beach refinery. Source: U.S. EIA - <https://www.eia.gov/state/analysis.php?sid=HI>.

¹⁵ Island Energy Services LLC (IES), a subsidiary of One Rock Capital Partners LP, New York, announced the close of refining operations of its 54,000-b/d Kapolei refinery in August 2018 as part of a shift in its strategic focus.

¹⁶ https://www.marathonpetroleum.com/content/documents/fact_sheets/Kenai_Refinery_Fact_Sheet.pdf.

2. VOLUME BALANCE

Propane production and import volumes are only available at the PADD level from EIA. Neither inter-PADD propane transfers nor state-specific non-prime supplier consumption are available in a public data source. Due to the limitations of available data, a volume balance approach was selected as the primary method for tracking the volume of propane in and out of California.¹⁷ Movements in and out of PADD 5 were evaluated as a whole.

As stated above, fuel production data is published at the PADD level; the system boundary for the volume balance performed for this study focused on PADD 5 (West Coast), which includes Arizona, California, Nevada, Oregon, and Washington State. As previously discussed in Section 1, PADD 5 West Coast also includes Alaska and Hawaii, but these states were excluded from the boundary.

Fundamental to the volume balance method is the presupposition that the propane market is in equilibrium. Equilibrium occurs when the quantity of propane demanded in the time period equals the quantity of propane supplied in that time period. In other words, the volumes of propane entering or leaving stockpiles are balanced. Propane inflow, then, refers to the volume of propane entering the system boundary, and outflow refers to the volume of propane leaving the system boundary. When the difference between the volume in and volume out equals zero, the system is in equilibrium.

This section describes each step in the volume balance approach with additional details and a complete list of data sources presented in Section 2.4.

2.1. Production and Imports

Within PADD 5, propane is produced in California and Washington State as a result of oilfield operations and refinery locations. Propane is imported to PADD 5 from other North American locations including PADD 2 Midwest, PADD 4 Rocky Mountain, and Canada. Additional propane is imported from the rest of the world (ROW) via the International Ports of Los Angeles and San Francisco from Argentina, Chile, South Korea, Norway, Peru, and Trinidad and Tobago. This section details California's production and imports of propane from petroleum refineries and natural gas plants.

Production

Propane is a by-product of both crude oil refining and natural gas processing within the PADD 5 region. The production totals for each production method are published by the U.S. Energy Information Administration (EIA).^{18 19} The production totals by production method for each state in PADD 5 were determined using the EIA PADD 5 totals together with information about the refineries operating in each state.

Production by Petroleum Refineries

Average daily propane production values, provided in thousand barrels per day, for each month obtained from EIA were converted to gallons and used to determine an annual production total for PADD 5. In

¹⁷ California production data was obtained from the Energy Commissioner, at request.

¹⁸ U.S. EIA, West Coast (PADD 5) Refinery and Blender Net Production of Propane, Source Key MPARP_R50_2.

¹⁹ U.S. EIA West Coast (PADD 5) Field Production of Propane (Source Key -M_EPLLPA_FPF_R50_MBBLD).

2018, 563,346 thousand gallons of propane were produced by refinery in PADD 5.²⁰ For reference, the unit conversion calculation is provided below.

PADD 5 Propane Production Total by Refinery (thousand gallons per year) =

$$\sum_{n=1}^{n=12} \text{Days in Month}_n \times \text{PADD 5 Production}_n (\text{kbbl/day}) \times 42 (\text{gallon/bbl}) =$$

The following section describes the production of propane by petroleum refineries for each state in PADD 5. Table A-1 in Appendix A provides a complete list of refineries within PADD 5.

Arizona and Oregon

No propane from refineries is produced in Arizona and Oregon as there are no petroleum refineries operating in these states.^{21 22}

California

In 2018, California had fifteen operational refineries with a combined capacity of 1.9 million barrels of crude per calendar day.²³ The California Energy Commission (CEC) tracks the total propane produced by refineries in the state and reported the total in 2018 to be 411,936 thousand gallons.²⁴

Nevada

Nevada has one small refinery, the Foreland Eagle Springs Refinery located in Ely, White Pine County, with a crude capacity of 2,000 barrels per calendar day.²⁵ Based on Air Permit Number AP2911-0905.04 issued December 10, 2018, the facility operates two propane-fired boilers and does not have a designated propane loading rack.²⁶ Based on this information, the propane produced by this refinery is assumed to be used on-site and no propane is supplied to the market from refineries in Nevada.

Washington State

In 2018, five refineries operated within Washington State with a joint capacity of 651,700 barrels of crude per calendar day. In order of greatest capacity, the operational refineries were BP Cherry Point, Shell Anacortes, Marathon Anacortes, Phillips 66 Ferndale, and U.S. Oil Tacoma.²⁷

²⁰ U.S. EIA, West Coast (PADD 5) Refinery and Blender Net Production of Propane, Source Key MPARP_R50_2.

²¹ U.S. EIA, Number and Capacity of Petroleum Refineries, Total Number of Operable Refineries.

²² U.S. EIA, Oregon Number of Operable Refineries as of January 1, 2019.

²³ California Energy Commission. Source: https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html.

²⁴ Dataset provided by California Energy Commission via email dated 12-2-2019 from Gordon Schremp, Senior Fuels Specialist to Sarah Backes, John Beath Environmental.

²⁵ American Fuel and Petrochemical Manufacturers United States Refining and Storage Capacity Report January 1, 2019 Published August 2019.

²⁶ Nevada Department of Environmental Quality Document Viewer, Air Pollution Control.

Source: <https://ndep.nv.gov/air>.

²⁷ Capacity obtained from the AFPM United States Refining and Storage Capacity Report. Source: <https://www.afpm.org/system/files/attachments/AFPM-Capacity-Report-2019.pdf>.

Propane production data for Washington could not be obtained from publicly-available sources. As the production totals for PADD 5 and California, the only other state within PADD 5 known to have refineries, were available, the total for Washington was back-calculated using a volume balance approach as shown below.

$$\begin{aligned}
 WA_{Ref} &= PADD\ 5_{Ref} - AZ_{Ref} - CA_{Ref} - NV_{Ref} - OR_{Ref} \\
 WA_{Ref} &= 563,346 - 0 - 411,936 - 0 - 0 \text{ (thousand gallons)} \\
 WA_{Ref} &= 151,410 \text{ thousand gallons}
 \end{aligned}$$

where,

WA_{Ref} = Propane production by Washington State refinery in thousand gallons

$PADD\ 5_{Ref}$ = Propane production by PADD 5 refinery in thousand gallons

AZ_{Ref} = Propane production by Arizona refinery in thousand gallons

CA_{Ref} = Propane production by California refinery in thousand gallons

NV_{Ref} = Propane production by Nevada refinery in thousand gallons

OR_{Ref} = Propane production by Oregon refinery in thousand gallons

Table 2-1 provides the volume of propane produced by each state within PADD 5 in 2018. The value of 151,410 thousand gallons shown for Washington is shaded blue to indicate the value is calculated using the aforementioned volume balance approach. Non-shaded values are based directly on publicly-available datasets.

Table 2-1 PADD 5 propane production by state and production method.

Values for 2018 shown in thousand gallons. Blue cells indicate cases where values have been calculated as the difference between the PADD 5 total and the known values for all other PADD 5 states.

<i>Region</i>	<i>Petroleum Refineries</i>	<i>Natural Gas Plants</i>	<i>Total</i>
Arizona	0	0	0
California	411,936	154,560	566,496
Nevada	0	0	0
Oregon	0	0	0
Washington	151,410	0	151,410
PADD 5 Total	563,346	154,560	717,906

Production by Natural Gas Plants.

PADD 5 Total

Average daily propane production values, provided in thousand barrels per day, for each month obtained from EIA were converted to gallons and used to determine an annual production total for PADD 5. In 2018, 154,560 thousand gallons of propane were produced by natural gas plant in PADD 5.²⁸ For reference, the unit conversion calculation is provided below.

²⁸ U.S. EIA West Coast (PADD 5) Field Production of Propane (Source Key -M_EPLLP_FPF_R50_MBBLD).

PADD 5 Propane Production Total by Natural Gas Plant (thousand gallons per year) =

$$\sum_{n=1}^{n=12} \text{Days in Month}_n \times \text{PADD 5 Production}_n \text{ (kbbl/day)} \times 42 \text{ (gallon/bbl)}$$

Arizona

Arizona has no significant natural gas reserves.²⁹ While, Arizona is home to one natural gas processing plant, Bonanza Creek Energy's Dorcheat Gas Processing Plant, it did not produce propane in 2018.³⁰ Thus, the production total for propane produced by natural gas plants in Arizona is zero.

Nevada

Nevada did not produce propane from natural gas plants as it had no natural gas plants operating within the state in 2018.³¹

Oregon

Oregon has limited natural gas reserves and accounts for less than 0.002% of the nation's natural gas production.³² While the Mist field in northwestern Oregon is a potential source, its gas deposits have a composition consisting of less than 0.01% propane.³³ Thus, propane production for Oregon by natural gas plants is estimated to be zero.

Washington

There are no natural gas processing facilities in Washington³⁴, and therefore the production total for natural gas plants is zero.

California

While the CEC tracks propane produced at refineries, propane produced at natural gas plants in California is not tracked in a publicly-available dataset. As the production total for natural gas plants in PADD 5 is known and the only state with propane production capacity via natural gas plants is California, its total production from natural gas plants is set equal to the total value reported for natural gas plants in PADD 5.

Table 2-1 provides a complete tabulation of propane production for PADD 5 in 2018.

²⁹ U.S. EIA, Natural Gas Reserves Summary as of December 31, 2017.

³⁰ U.S. Securities and Exchange Commission Form 10-K for Bonanza Creek Energy's Dorcheat Gas Processing Plant.

³¹ U.S. EIA Natural Gas Annual Respondent Query System (EIA-757).

³² U.S. EIA, Natural Gas Proved Reserves, Miscellaneous, Annual 2018.

³³ U.S. EIA, Natural Gas Gross Withdrawals and Production, Dry Production, 2018.

³⁴ U.S. EIA Natural Gas Annual Respondent Query System (EIA-757).

Imports

PADD 5

On an annualized basis, in 2018 PADD 5 consumed more propane than is produced; thus, significant volumes were imported into the region. The largest propane contributor for PADD 5 was Canada which accounted for over 70% of imports into the region in 2018.³⁵ Based on datasets published by EIA, propane from Canada entered PADD 5 almost exclusively by rail.³⁶

In addition to imports from Canada, EIA data indicates that PADD 5 imported 14.7% of its total propane from PADD 2, 8% from PADD 4, and 4.1% from a handful of Non-OPEC countries primarily located in the Caribbean and South America.³⁷ Domestic imports of propane transferred from PADD 2 and PADD 4 into PADD 5 moved by rail and truck. To date, no natural gas liquid (NGL) or hydraulic grade line (HGL) pipelines are present in PADD 5.

**Each import region is shaded a unique color to highlight origin location of imported propane to PADD 5*

Figure 3 Origin of propane imported to PADD 5 in 2018.

³⁵ Canadian International Merchandise Trade Database, Table 980-0027 - Domestic exports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquefied Propane.

³⁶ U.S. EIA dataset, West Coast (PADD 5) Receipts by Rail from Canada of Propane, source key ESM_EPLLPA_RAIL_R50-NCA_MBBL.

³⁷ U.S. EIA dataset, imports by country of origin.

https://www.eia.gov/dnav/pet/pet_move_impcp_a2_r50_EPLLPA_IM0_mbbldpd_m.htm.

**Each import region is shaded a unique color to highlight origin location of imported propane to California*

Figure 4 Origin of propane imported to California in 2018.

Non-Canadian international imports enter PADD 5 through the Port of Los Angeles and Port of San Francisco, California.³⁸ The Port of Seattle is an export terminal for propane; historically the port has received imported propane from Russia, but in 2018 it did not. Refer to Figure 3, for an overview of all imports that entered PADD 5 in 2018.

California

In 2018, California received domestic imports of propane, both from outside PADD 5 and from inter-PADD 5 transfers. Additionally, California received propane from Canada, Argentina, Chile, Peru, Norway, South Korea, and Trinidad and Tobago. Figure 4 displays each origin of propane import to California along with each location's percent of total imports.

PADD 2

Propane transfers from PADD 2 to PADD 5 were 109,872 thousand gallons.³⁹ To determine which states within PADD 5 received propane from PADD 2, transportation infrastructure, transport distance, price in the origin market, commodity shortage in individual PADD 5 states, and propane storage ability within individual states were evaluated.

³⁸ U.S. EIA and ITC datasets are used to confirm California is the destination for Non-Canadian foreign imports that move through the ports of California.

³⁹ U.S. EIA West Coast (PADD 5) Receipts by Pipeline, Tanker, Barge and Rail from Midwest (PADD 2) of Propane (Source Key: M_EPLLPA_TNR_R50-R20_1).

Table 2-2 provides the distance from the midpoint of the western border PADD 2 states with propane production capability, Oklahoma, Kansas, North Dakota, and South Dakota, to the midpoint of PADD 5 states, and propane prices in the producing regions. Note Nebraska is excluded from the analysis shown in Table 2-2 as there are no petroleum refineries or natural gas plants within the state. The values in Table 2-2 are shaded from light to dark, where the darker colored cells represent the shortest distance from the midpoint of the paired states. For example, the longest transport route displayed in Table 2-2, is Oklahoma to Washington State at 1,955 miles, and the shortest route is Oklahoma to Arizona at 934 miles.

Table 2-2 Distance in miles from mid-state for PADD 2 western border states to PADD 5 states and propane price in origin market.

<i>Region</i>	<i>Oklahoma</i>	<i>Kansas</i>	<i>South Dakota</i>	<i>North Dakota</i>
Arizona	934	1,200	1,246	1,491
California	1,500	1,740	1,644	1,714
Nevada	1,429	1,424	1,245	1,289
Oregon	1,800	1,635	1,365	1,335
Washington	1,955	1,765	1,325	1,196
Annual Avg Price (U.S. dollar/gallon)	0.89	0.83	0.84	0.80

Based on transport distance, a large in-state propane demand, the presence of PADD 5's largest propane storage facility, and the market route from Arizona to Mexico, the most reasonable scenario is that Arizona received all imported propane from PADD 2 to PADD 5.⁴⁰ Thus, this analysis estimates all 109,872 thousand gallons of propane transferred from PADD 2 were destined for Arizona.

PADD 4

Inter-PADD propane transfers to PADD 5, including those from PADD 4, were 59,724 thousand gallons in 2018 based on EIA data.⁴¹ Similar to the analysis for PADD 2, to determine which states within PADD 5 received propane from PADD 4, transportation routes, demand, and known supply in individual PADD 5 states was evaluated – starting with states with no production or export of propane. The example for Nevada is shown in the table below for reference. The same approach was used for the remaining states in PADD 5.

⁴⁰ While the cost of propane from PADD 2 states was evaluated, it was not a critical factor in the assumption that propane from PADD 2 routes to Arizona, exclusively (within PADD 5).

⁴¹ U.S. EIA West Coast (PADD 5) Receipts by Pipeline, Tanker, Barge and Rail from Rocky Mountain (PADD 4) of Propane (Source Key: M_EPLLPA_TNR_R50-R40_1).

Table 2-3 Example volume balance approach used for PADD 4 transfers to PADD 5.
Values given in thousand gallons.

<i>Propane Flow</i>	<i>Nevada</i>
Production	0
Imports	
PADD 2	0
PADD 4	17,853
Inter-PADD 5	0
Canada	23,591
ROW	0
Exports	0
Consumption	41,444
Production + Imports – Exports - Consumption	0

Inter-PADD 5

Inter-PADD 5 transfers were estimated using a similar approach to that outlined for PADD 4 to PADD 5 transfers, i.e., transportation routes, demand, and known supply in individual PADD 5 states is evaluated and a volume balance applied. For Arizona, the total volume of propane exported from California via rail for 2018 was 772 thousand gallons according to data published by the CEC, and the total domestic imports of propane to California for 2018 was 19,961 thousand gallons according to CEC.⁴² The total volume was distributed between PADD 4 and inter-PADD 5 receipts.⁴³

Canada

Statistics Canada's International Merchandise Trade Database publishes actual volumes imported from Canada into the U.S. at the state level.⁴⁴ Therefore, the actual imported volume for each state within PADD 5 was specified by the Statistics Canada data. Refer to Table 2-4 for 2018 values.

For Washington State, the Canadian International Merchandise Trade Database published an import total of 347,893 thousand gallons for 2018.⁴⁵

⁴² Dataset provided by California Energy Commission via email dated 12-2-2019 from Gordon Schremp, Senior Fuels Specialist to Sarah Backes, John Beath Environmental.

⁴³ California Energy Commission, Propane Volume Balance, Domestic Rail Imports 2018.

⁴⁴ Canadian International Merchandise Trade Database, Table 980-0027 - Domestic exports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquified Propane.

⁴⁵ Canadian International Merchandise Trade Database, Table 980-0027 - Domestic exports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquified Propane.

Rest of World

The EIA publishes actual volumes of propane imported into PADD 5 by year. Additionally, the U.S. International Trade Commission (ITC) tracks the port of entry for all ocean freight imports at the commodity level.^{46,47} The volume of imported propane for each state within PADD 5 was determined by leveraging these two datasets. Refer to Table 2-4 for 2018 values.

2.2. Consumption and Exports

This section describes the consumption of propane in California and its export from the state. North American exports in 2018 included a small portion of exchange to Canada from Washington State and exports to Mexico from California and Arizona. The Ports of Los Angeles, California and Seattle, Washington historically export to countries in Asia and Oceania. The full trade flows are described in the following section.

Consumption

Propane consumption for Prime Supplier Sales is published by the EIA at the state level. This dataset is based on survey responses from suppliers who completed Form EIA-782C.⁴⁸ EIA-782C volumes are designed to measure prime supplier sales into only the local markets of final consumption. By its design, Form EIA-782C volumes exclude sales to any company that is not a local distributor, local retailer, or end user. Additionally, sales to refiners, interstate resellers, importers, traders, and retailers who transport products across state boundaries are excluded (since these are not classified as prime supplier sales). As such, to create a balanced market within the volume balance, propane consumption volumes were increased for states such as California and Washington State with heavy refining presence to account for the use of propane as a raw material or feedstock.

Exports

Exports to U.S. PADDs

Based on EIA published data, PADD 5 did not export propane to any other U.S. PADD.⁴⁹

Inter-PADD 5 Exports

Arizona, Nevada, and Oregon do not produce propane, and therefore these states do not contribute to the PADD 5 export total. CEC provides the volume of propane exported from California for domestic export by rail. According to EIA propane transportation route maps, all domestic exports from California are transported to Arizona for storage or immediate use.

⁴⁶ The United States International Trade Commission's Dataweb, Commodity Code 271112, Liquefied Propane.

⁴⁷ U.S. EIA PAD District Imports by Country of Origin (Source Key -MPAIM_R50-MN0_2).

⁴⁸ U.S. EIA Propane All Sales/Deliveries by Prime Supplier (Source Keys C900050041, C900050061, C900050321, C900050411, and C900050531).

⁴⁹ U.S. EIA Midwest (PADD 2) Receipts by Pipeline, Tanker, Barge and Rail from West Coast (PADD 5) of Propane (Source Key M_EPLLP_A_TNR_R20-R50_1); and, U.S. EIA Rocky Mountain (PADD 4) Receipts by Pipeline, Tanker, Barge and Rail from West Coast (PADD 5) of Propane (Source Key M_EPLLP_A_TNR_R40-R50_1).

As Washington state is both a large producer and an importer of propane, a volume analysis was performed to balance the state of Oregon's demand by estimating the propane demand in Oregon was satisfied via imports from Washington. The propane freight rail line running from Seattle, Washington to Portland, Oregon is one likely transfer route. The net propane flows indicate Washington also sends propane to California. The total propane domestically imported to California for 2018 is provided by the CEC; this analysis assumes a portion of that total originates from Washington.

Canada

Small volumes of propane were exported from Washington to Canada; additionally, no other PADD 5 state exported to Canada in 2018. As for Canadian imports, exports from the U.S. into Canada are tracked at the state level via Statistics Canada's International Merchandise Trade Database.⁵⁰ The 2018 actual exported volumes for each state within PADD 5 are provided in Table 2-4.

Mexico

California exported propane to Mexico via rail and truck moving through the Cross-Border Production Region of San Diego and Baja California, Mexico. Almost all of the propane exports from California are destined for Mexico. Actual 2018 volumes and port of exit locations are provided by the U.S. ITC.⁵¹

Arizona also exported propane to Mexico via rail and truck with passage through Nogales, Arizona. In 2018, all exports from Arizona were destined for Mexico.

Rest of World

Within PADD 5, only California and Washington exported outside of North America. Less than 1% of California's propane exports went to Rest of World (ROW) countries where the exports exit the state at the Port of Los Angeles. Washington is one of the nation's largest exporters of propane, historically delivering substantial fuel supply to Asia. Export volumes for 2018 are provided by the U.S. ITC.⁵²

2.3. Volume Balance Results

The comprehensive propane balance for PADD 5 is presented in Table 2-4, including the breakout for individual states and as well as the PADD 5 aggregate results.

⁵⁰ Canadian International Merchandise Trade Database, Table 990-0027 27 - Imports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquefied Propane.

⁵¹ The United States International Trade Commission's Dataweb. Search Query Parameters include: Trade Flow - Total Exports; Classification System - HTS Items; Data To Report - First Unit of Quantity; Actual Data - 2018; Commodity 271112, Propane, Liquefied.

⁵² The United States International Trade Commission's Dataweb. Search Query Parameters include: Trade Flow - Total Exports; Classification System - HTS Items; Data To Report - First Unit of Quantity; Actual Data - 2018; Commodity 271112, Propane, Liquefied.

Table 2-4 Propane volume balance for PADD 5.

Values for 2018 provided in thousand gallons.

<i>Parameter</i>	<i>Arizona</i>	<i>California</i>	<i>Nevada</i>	<i>Oregon</i>	<i>Washington</i>	<i>PADD 5 Total</i>
Production						
In State Production	0	566,496	0	0	151,410	717,906
Imports (by origin)						
PADD 2	109,872	0	0	0	0	109,872
PADD 4	31,076	10,795	17,853	0	0	59,724
Inter-PADD 5	772	9,166	0	13,823	0	23,761
Canada	27,697	78,738	23,591	46,873	347,893	524,792
ROW	0	30,954	0	0	0	30,954
Consumption						
Prime Supplier Sales	94,295	457,572	41,444	60,696	213,737	867,743
Non-Prime Supplier Sales	0	131,209	0	0	12,709	143,918
Exports (by destination)						
Other U.S. PADDs	0	0	0	0	0	0
Inter-PADD 5	0	772	0	0	22,988	23,761
Canada	0	0	0	0	6,709	6,709
Mexico	75,123	106,247	0	0	0	181,370
ROW	0	348	0	0	243,159	243,508
Production + Imports	169,418	696,149	41,444	60,696	499,303	1,467,009
Consumption + Exports	169,418	696,149	41,444	60,696	499,303	1,467,009

Calculated value using volume balance approach
Estimated based on analysis of propane market, propane infrastructure, pricing, etc.
Actual volume obtained from publicly available dataset

**Prime supplier sales quantify consumption to local markets for final consumption; it excludes sales to refiners, interstate resellers, importers, traders, and retailers who transport products across state boundaries and companies that are not a local distributor, local retailer, or end user*

Table 2-5 Key data sources – 2018 refinery propane production within U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
Arizona refinery propane production	0	kgal	Arizona has no petroleum refineries.	U.S. EIA, Number and Capacity of Petroleum Refineries, Total Number of Operable Refineries.
California refinery propane production	411,936	kgal	-	Gordon Schremp, Senior Fuels Specialist, California Energy Commission.
Nevada refinery propane production	0	kgal	Nevada has one refinery, the Foreland Ely/Eagle Springs Refinery; the facility is not permitted to load propane and operates two propane-fired boilers. Based on the use of propane-fired sources, it is estimated any produced propane would be used within the facility's gate and not sold.	Air Permit Number AP2911-0905.04 issued December 10, 2018 obtained from the Nevada Division of Environmental Protection's Public Document Viewer.
Oregon refinery propane production	0	kgal	Oregon does not have any operating petroleum refineries.	U.S. EIA, Oregon Number of Operable Refineries as of January 1, 2019.
Washington State refinery propane production	151,410	kgal	Calculated by subtracting the total propane production at refinery from Arizona, California, Nevada, and Oregon by the PADD 5 total propane production at refinery.	Calculated using datasets from U.S. EIA, West Coast (PADD 5) Refinery and Blender Net Production of Propane, Source Key MPARP_R50_2 and Gordon Schremp, Senior Fuels Specialist, California Energy Commission.
PADD 5 refinery propane production	563,346	kgal	Average daily propane production values for each month were used to determine an annual production value for PADD 5. Units of barrel were converted to gallon using a conversion factor of 1 barrel propane equals 42 gallons.	U.S. EIA, West Coast (PADD 5) Refinery and Blender Net Production of Propane, Source Key MPARP_R50_2.

Table 2-6 Key data sources – 2018 natural gas plant propane production within U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
Arizona - propane production by natural gas plant	0	kgal	Arizona has no significant natural gas reserves. The only operating natural gas processing plant, Bonanza Creek Energy's Dorcheat Gas Processing Plant, does not produce any natural gas liquids (NGLs) which would include propane.	U.S. Securities and Exchange Commission Form 10-K for Bonanza Creek Energy's Dorcheat Gas Processing Plant; and, U.S. EIA, Natural Gas Reserves Summary as of December 31, 2017.
California - propane production by natural gas plant	154,560	kgal	Calculated by subtracting the total propane production at natural gas plants from Arizona, Nevada, Oregon, and Washington by the PADD 5 total propane production at natural gas field.	U.S. EIA West Coast (PADD 5) Field Production of Propane (Source Key - M_EPLLPA_FPF_R50_MBBLD).
Nevada - propane production by natural gas plant	0	kgal	Nevada has no natural gas processing plant capacity.	U.S. EIA Natural Gas Annual Respondent Query System (EIA-757).
Oregon - propane production by natural gas plant	0	kgal	Oregon has few natural gas reserves and accounts for less than 0.002% of the nation's natural gas production. The Mist field in northwestern Oregon is the only natural gas field in the Pacific Northwest. The Mist field gas composition consists of less than 0.01% propane. Thus, the propane production for Oregon is estimated at approximately zero.	U.S. EIA, Natural Gas Proved Reserves, Miscellaneous, Annual 2018; and, U.S. EIA, Natural Gas Gross Withdrawals and Production, Dry Production, 2018.
Washington State - propane production by natural gas plant	0	kgal	Washington State has no natural gas processing plant capacity.	U.S. EIA Natural Gas Annual Respondent Query System (EIA-757).
PADD 5 - propane production by natural gas plant	154,560	kgal	Average daily propane production values for each month were used to estimate an annual production value for PADD 5.	U.S. EIA West Coast (PADD 5) Field Production of Propane (Source Key - M_EPLLPA_FPF_R50_MBBLD).

Table 2-7 Key data sources - propane consumption within U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
2018 In State Propane Consumption - Prime Supplier Sales for PADD 5	867,743	kgal	Calculated PADD 5 value by aggregating total for Arizona, California, Nevada, Oregon, and Washington State.	U.S. EIA Propane All Sales/Deliveries by Prime Supplier (Source Keys C900050041, C900050061, C900050321, C900050411, and C900050531)
In State Consumption - Estimated Addition for States with Propane Raw Materials	131,209	kgal	Calculated value. A volumetric balance for California was used to determine the amount of additional consumption required in-state to balance the state's propane in-take and out-take.	Calculation

Table 2-8 Key data sources - propane imports within U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
2018 propane imports from PADD 2 to PADD 5	109,872	kgal	Monthly total propane transfer from PADD 2 to 5 was provided in units of thousand barrel and converted to thousand gallon using a conversion factor of 1 barrel propane equals 42 gallons.	U.S. EIA West Coast (PADD 5) Receipts by Pipeline, Tanker, Barge and Rail from Midwest (PADD 2) of Propane (Source Key: M_EPLLP_A_TNR_R50-R20_1)
2018 propane imports from PADD 4 to PADD 5	59,724	kgal	Monthly total propane transfer from PADD 4 to 5 was provided in units of thousand barrel and converted to thousand gallon using a conversion factor of 1 barrel propane equals 42 gallons.	U.S. EIA West Coast (PADD 5) Receipts by Pipeline, Tanker, Barge and Rail from Rocky Mountain (PADD 4) of Propane (Source Key: M_EPLLP_A_TNR_R50-R40_1)
2018 propane imports from Canada to Arizona, California, Nevada, Oregon, and Washington State	524,792	kgal	Data provided monthly in units of hectoliter and converted to thousand gallon using conversion factor 1 hectoliter equals 26.4172 U.S. gallons.	Canadian International Merchandise Trade Database, Table 980-0027 - Domestic exports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquefied Propane.

2018 propane imports from PADD 2 to PADD 5 to Arizona	109,872	kgal	Based on distance from the midpoint of Western outer PADD 2 states with propane production capability (Oklahoma, Kansas, North Dakota, and South Dakota) to the midpoint of PADD 5 states, annual average propane price, propane infrastructure, EIA publications, and the in-state propane balance for PADD 5 states, the most likely destination for propane exported from PADD 2 to PADD 5 is to Arizona. Note Arizona is home to a large propane storage facility utilized by PADD 5.	Propane Market Fundamentals for Upper Peninsula Energy Task Force Published November 13, 2019, Warren Wilczewski, Industry Economist.
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Continued. Key data sources - propane imports within U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
2018 Inter-PADD 5 Imports to Arizona	772	kgal	Actual volume exported from California by domestic rail for 2018 is the basis of volume.	California Energy Commission; U.S. EIA Propane Transportation and Storage Maps
2019 Inter-PADD 5 Imports to Oregon	13,823	kgal	Estimated using a volumetric balance approach, where the imbalance of consumption versus production is balanced via inter-PADD imports. This analysis estimated Oregon imports the difference in supply and demand to meet state consumption needs from Washington State.	Calculation

2020 Inter-PADD 5 Imports to California	9,166	kgal	The total domestic import value into California for 2018 is provided by the California Energy Commission. Based on EIA maps, a portion of the total known value is designated to California, originating from Washington State.	California Energy Commission; U.S. EIA Propane Transportation and Storage Maps
2018 propane imports from rest of world	30,954	kgal	Within PADD 5 only California and Washington State receive imported propane from ROW. Washington State only receives imports from Canada and Russia - though Russian imports were 0 barrels in 2018. Thus, all imports are allotted to California. No foreign imports were listed for Arizona, Nevada or Oregon.; thus indicating zero.	The United States International Trade Commission's Dataweb (provided port of entry locations); U.S. EIA PAD District Imports by Country of Origin (Source Key -MPAIM_R50-MN0_2)

Table 2-9 Key data sources - propane exports from U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
2018 propane exports from PADD 5 to other U.S. PADDs	0	kgal	In 2018, PADD 5 did not export propane to any other U.S. PADD.	U.S. EIA Midwest (PADD 2) Receipts by Pipeline, Tanker, Barge and Rail from West Coast (PADD 5) of Propane (Source Key M_EPLLP_A_TNR_R20-R50_1); and, U.S. EIA Rocky Mountain (PADD 4) Receipts by Pipeline, Tanker, Barge and Rail from West Coast (PADD 5) of Propane (Source Key M_EPLLP_A_TNR_R40-R50_1).

2018 propane inter-PADD 5 exports from California to PADD 5	772	kgal	The domestic export by rail from California remains in PADD 5 and is transferred by rail to Arizona according to EIA datasets for domestic HGL movement.	Gordon Schremp, Senior Fuels Specialist, California Energy Commission; and, U.S. Energy Information Administration, Petroleum Supply Monthly - HGL Movements by Rail - Warren Wilczewski.
2018 propane inter-PADD 5 exports from Washington State to Oregon	13,823	kgal	Calculated - using a volumetric balance approach, the volume needed for Oregon to balance consumption and imported propane is set equal to the imported amount from Washington State.	Calculated

Table 2-9 Continued. Key data sources - propane exports from U.S. PADD 5.

Data Input	Value/Unit		Key Notes	Source
2018 propane exports from PADD 5 to Canada	6,709	kgal	Data provided monthly in units of hectoliter and converted to thousand gallon using conversion factor 1 hectoliter equals 26.4172 U.S. gallons. In 2018, only Washington exported propane to Canada.	Canadian International Merchandise Trade Database, Table 990-0027 27 - Imports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquefied Propane.

2018 propane exports from Washington to Canada	6,709	kgal	Exported volume varied by data source location. The higher volume was used. Values differ 12.2% - 140,197 bbl compared to 159,739 bbl. Data was provided in barrels and converted to gallon using a conversion factor of 1 barrel propane equals 42 gallons.	Canadian International Merchandise Trade Database, Table 990-0027 27 - Imports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes, Commodity Code 271112, Liquefied Propane; and, The United States International Trade Commission's Dataweb. Search Query Parameters include: Trade Flow - Total Exports; Classification System - HTS Items; Data To Report - First Unit of Quantity; Actual Data - 2018; Commodity 271112, Propane, Liquefied.
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Table 2-9 (continued). Key data sources - propane exports from U.S. PADD 5.

Data Input	Value/Unit	Key Notes	Source
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2018 propane exports from PADD 5 to Mexico	181,370	kgal	Original data was provided on an annual basis where values were provided by state export location for Arizona and California. No domestic exports were listed for Nevada, Oregon, or Washington to Mexico.; thus indicating zero exports to Mexico. Data was provided in barrels and converted to gallon using a conversion factor of 1 barrel propane equals 42 gallons.	The United States International Trade Commission's Dataweb. Search Query Parameters include: Trade Flow - Total Exports; Classification System - HTS Items; Data To Report - First Unit of Quantity; Actual Data - 2018; Commodity 271112, Propane, Liquefied.
2018 actual propane exports from PADD 5 to rest of world (Outside North America)	243,508	kgal	Original data was provided on an annual basis where values were provided by state export location for California and Washington State. Data was provided in barrels and converted to gallon using a conversion factor of 1 barrel propane equals 42 gallons.	The United States International Trade Commission's Dataweb. Search Query Parameters include: Trade Flow - Total Exports; Classification System - HTS Items; Data To Report - First Unit of Quantity; Actual Data - 2018; Commodity 271112, Propane, Liquefied.

3. PRODUCTION METHOD BY SOURCE REGION

As previously described, propane is produced as a by-product of petroleum refineries, natural gas plants, and bitumen extraction. For each region of origin, the production method for the total volume of propane produced or exported to California is determined based on production data. This information is used together with the production and trade flows from Section 2 to specify the production method for the propane consumed in California from each source region.

3.1. Production Method Fraction for Propane Consumed within California

In-State Production

As discussed in Section 2, California produces propane at both petroleum refineries and natural gas plants. In 2018, 72.7% of the propane produced in-state was by refinery, with 27.3% produced by natural gas plant. The distribution by production method is provided in Table 3-1.⁵³

Figure 5 provides an overview of all refineries and natural gas plants operating within California, supplemented by a list of plants in Tables A-1 and A-2 of Appendix A to this report.

Table 3-1 Propane distribution by production method for California in-state production.

<i>Propane Source</i>	<i>Production</i>	
	<i>Thousand gallons</i>	<i>Shares of Total</i>
Petroleum Refineries	411,936	72.7%
Natural Gas Plants	154,560	27.3%
Total Production	566,496	

⁵³ Based on dataset obtained from the California Energy Commission.

**Map overlay provided by mapline software*

Figure 5 Map of refineries and natural gas plants in California.

Domestic Imports

Inter-PADD Imports

As Washington is the only state in PADD 5, other than California, to produce propane, all inter-PADD 5 exports to California are estimated to originate from Washington. As previously discussed in Section 2, Washington has no natural gas plants – only refineries; thus, all inter-PADD 5 imports to California are assumed to be produced by refinery. Note the assumption that all propane originating from Washington was produced at a refinery is conservative, since propane could have been imported into Washington initially from Canada and then passed through to California. Section 5 provides sensitivity analysis results related to this assumption.

Domestic Imports from PADD 4 to PADD 5

The analysis presented here estimates propane transfers from PADD 4 to California. States within PADD 4 produce propane from both refineries and natural gas plants. The production shares by refineries and natural gas plants are based on their shares in the PADD 4 production mix.^{54, 55} These shares are presented in Table 3-2.

Table 3-2 Propane distribution by production method for California, domestic imports.

<i>Propane Source</i>	<i>PADD 4 Production thousand gallons</i>	<i>Shares of Total</i>	<i>Inter-PADD 5 Imports from Washington thousand gallons</i>	<i>Shares of Total</i>
Petroleum Refineries	127,638	5.3%	151,410	100%
Natural Gas Plants	2,274,426	94.6%	0	0%
Total Production	566,496		151,410	

Canadian Imports

California received 61% of its propane imports from Canada, where propane is produced by petroleum refineries, natural gas plants, and bituminous sands upgrader and fractionator operations. Oil sands extraction is not performed in the U.S. since these types of reserves have only been discovered in Utah and have not been found to be economically viable at a commercial scale to date.⁵⁶ Oil sands operations in Canada are discussed below.

Refinery

The refining capacity by facility is provided in Appendix B. Based on transport distance and existing rail line infrastructure between Canada and PADD 5, this analysis assumes propane produced by refineries in British Columbia, Alberta, and Saskatchewan provinces could potentially be exported to California. Based on Statistics Canada's Supply and Disposition of Refined Petroleum Products, propane was not

⁵⁴ U.S. EIA, Rocky Mountain (PADD 4) Refinery and Blender Net Production of Propane (Source Key MPARP_R40_2).

⁵⁵ U.S. EIA, Rocky Mountain (PADD 4) Field Production of Propane (Source Key M_EPLLPA_FPF_R40_MBBLD).

⁵⁶ As of March 2020, capacity reached an economic break-even point at 300 bbl/day. Source: <https://petroteq.energy/news/press-releases/detail/344/petroteq-reaches-new-production-milestone-of-300-bblsday>.

sold in 2018 from the refineries in British Columbia. Thus, only propane sales from refineries in Alberta and Saskatchewan provinces could potentially be consumed in California.

Natural Gas Plants

As with the refineries, this analysis assumes propane produced by natural gas plants in Alberta, British Columbia, and Saskatchewan provinces are potentially exported to California. Each province reports propane production and sales data aggregated for all gas plants across the province. Propane sales from natural gas plants account for 100% of total propane from British Columbia, followed by 86% of propane from Saskatchewan and 63% of propane from Alberta. Refer to Table B-1 to Appendix B for a list of natural gas plants in this region.

Bituminous Sands Upgrader and Fractionator Operations

Bituminous sand upgrader and fractionator operations are present in the Alberta province. Bituminous sand upgrader and fractionator operations account for 3.6% of the total propane produced in Canada in 2018 –approximately 137 million gallons. Based on data obtained from the Alberta Energy Regulator, the propane produced at oil sand sites was presumed to be consumed on-site in 2018. Thus, in 2018 oil sands production accounted for 0% of the total volume of propane imported from Canada to PADD 5.⁵⁷

Note while propane is also produced in other provinces, the transport distances minimizes the likelihood that propane produced in other provinces is transported to California. Therefore, this analysis estimates Canadian imports were produced exclusively in British Columbia, Alberta, and/or Saskatchewan in 2018.

Table 3-3 provides the total propane sales by each production method – sold to all destinations from Alberta, British Columbia, and Saskatchewan provinces. Based on propane sales by production method, a fraction for each production method was determined; refer to Appendix C for a detailed emission calculation. This analysis assumes the production fraction for Alberta, British Columbia, and Saskatchewan provinces is equal to the production fraction for Canadian imports into PADD 5 and to California specifically. Table 3-3 shows 96.5% of Canadian propane imported to California is produced by natural gas production and 3.5% by petroleum refinery in 2018. Table 3-4 shows how these ratios were applied to California imports from Canada.

Table 3-3 2018 Propane sales for Canadian provinces: Alberta, British Columbia, and Saskatchewan, to all destinations.

<i>Propane Source</i>	<i>Alberta</i>	<i>British Columbia</i>	<i>Saskatchewa n</i>	<i>Total</i>	<i>Shares</i>
Petroleum Refineries	108,561	0	23,911	132,472	3.5%
Natural Gas Plants	2,940,895	520,792	142,773	3,604,460	96.5%
Bituminous Sands	0	0	0	0	

⁵⁷ Determination based on dataset provided by the Alberta Energy Regulator on July 6, 2020, file name '2018ntrlgslqds-eng.xlsx.

Table 3-4 Propane production for Canadian imports to PADD 5 and to California.
Values for 2018 shown in thousand gallons.

<i>Propane source</i>	<i>PADD 5</i>	<i>Shares</i>	<i>California</i>	<i>Shares</i>
Total Imports from Canada	524,792	100%	78,738	100%
Petroleum Refineries	18,604	3.5%	2,791	3.5%
Natural Gas Plants	506,189	96.5%	75,946	96.5%
Bituminous Sands	0	0%	0	0%

**Sales include only the provinces of Alberta, British Columbia, and Saskatchewan.*

Imports from Rest of World

California also receives propane from international trade with the rest of the world through its ports. While the volume of propane imported from each country to California is known, the shares of that propane by production method is not available in a public dataset. The production sources for propane imported from each trade partner was estimated using the approaches described in this section.

Estimate the Volume of Propane Produced by Refineries

In 2018, California received propane from Argentina, Chile, South Korea, Norway, Peru, and Trinidad and Tobago. All six countries operate refineries where the actual 2018 crude throughput is known. Using the known throughput and selecting a representative crude assay (or group of assays) for each country, the volume of propane produced by refinery for each country was estimated using the Petroleum Refinery Life Cycle Inventory Model (PRELIM).⁵⁸ Where multiple crude assays were run in PRELIM, the volume percent of propane produced at refinery for each crude type was arithmetically averaged to determine a single, representative volume percent for each country. Detailed calculations are provided in Appendix D.

Estimate the Volume of Propane Produced by Natural Gas Plants (via Field Production)

To estimate the total volume of propane produced by natural gas plant, a representative field gas composition (or group of compositions) was selected for each country that produced propane via natural gas plant in 2018: Argentina, South Korea, Norway, Peru, and Trinidad and Tobago. Where multiple field gas composition streams were used, the volume percent of propane for each field type was arithmetically averaged to determine a single, representative volume percent for each country.

For each region, the volume percent of propane determined based on field gas composition was used (where available publicly) along with the known volume of raw natural gas processed to estimate the volume of propane produced by natural gas plant. Where not available a process of designating field gas with known composition as a surrogate was used. For a detailed calculation, refer to Appendix D.

Determine the Production Ratio for each Country

The percent of propane produced by refineries and natural gas plants in each region was calculated by dividing production by these sources by the total production volume. The production fraction for each production method and country is provided in Table 3-5. Detailed calculations and supporting documentation are provided in Appendix D to this report. Additionally, refer to Table 3-8 for a list of data sources for each data parameter used to determine the production fractions for rest-of-world imports.

⁵⁸ Petroleum Refinery Life Cycle Inventory Model version 1.3, <https://www.ucalgary.ca/lcaost/prelim>.

Table 3-5 Propane production fractions for imports to California from the rest of the world.

Values for 2018 shown in thousand gallons.

<i>Source Country</i>	<i>Production</i>			<i>Shares</i>	
	<i>Petroleum Refineries</i>	<i>Natural Gas Plants</i>	<i>Total</i>	<i>Petroleum Refineries</i>	<i>Natural Gas Plants</i>
Argentina	49,715	781,814	831,530	6%	94%
Chile	12,920	0	12,920	100%	0%
South Korea	213,670	352,583	566,252	38%	62%
Norway	27,183	2,284,124	2,311,307	1%	99%
Peru	22,107	705,166	727,273	3%	97%
Trinidad and Tobago	8,347	306,594	314,941	3%	97%

Summary of Production Methods for Propane Exports by Origin Region

Table 3-6 provides the total volume as well as production method split for each propane stream contributing to consumption in California in 2018.

Table 3-6 California - propane production method fraction by source of origin.

<i>Parameter</i>	<i>Total thousand gallons</i>	<i>Refineries</i>	<i>Natural Gas Plants</i>	<i>Bituminous Sands (Oil Sands)</i>
Production, in state	566,496	73%	27%	0%
Imports				
PADD 2	0	-	-	-
PADD 4	10,795	5%	95%	0%
Inter-PADD 5 from Washington	9,166	100%	0%	0%
Canada	78,738	4%	96%	0%
Rest-of-world				
Argentina	2,940	6%	94%	0%
Chile	2,394	100%	0%	0%
Korea, South	2,352	38%	62%	0%
Norway	4,662	1%	99%	0%
Peru	2,352	3%	97%	0%
Trinidad and Tobago	16,254	3%	97%	0%

3.2. Assigning Production Method to Consumption

This analysis relies on the assumption that all propane imported to California, which is not otherwise specified for re-export, is consumed, and that the remaining in-state demand is met by in-state petroleum refining and natural gas processing operations. It also assumes flows into and out of propane stockpiles do not have a significant effect on the sources of or production methods for the propane consumed in California in 2018.

Table 3-7 Key data sources - propane production and sales data for propane imported to California from Canada.

Data Input	Value/Unit		Key Notes	Source
Canadian Propane Production Sales by Refinery - for Alberta British Columbia, and Saskatchewan Provinces	501,462	m ³	Data provided at the province level. In 2018, only Alberta and Saskatchewan provinces sold propane produced at a refinery.	Statistics Canada. Table 25-10-0044-01 Supply and disposition of refined petroleum products, monthly - Propane and propane mixes
Propane Production by Natural Gas Plant for Saskatchewan Province Canada	540,456	m ³	Actual 2018 production and sales data provided in units of cubic meters.	Government of Saskatchewan, 2018-02-26 Gas Plant Report.
Propane Production by Natural Gas Plant for Alberta Province Canada	30,500	m ³	Actual 2018 production provided in units of thousand cubic meters per day; converted to meters per year.	Alberta Energy Regulator, Figure S6.3 - Propane Supply from Natural Gas and Demand
Propane Production by Natural Gas Plant for British Columbia Province Canada	1,971,413	m ³	Actual 2018 production and sales data provided in units of cubic meters.	Government of British Columbia: Production of propane, butane, and pentanes plus, B.C. By-Products Production.xls.
Canadian Sales of Bituminous Sands	0	Mb/d	All Canadian bituminous sand operations occur in Alberta Province.	Alberta Energy Regulator, Canada's Energy Future 2018 Supplement: Natural Gas Liquids Supply and Disposition

Table 3-8 Key data sources - production fractions for propane produced in ROW and imported to California.

Data Input	Value/Unit		Key Notes	Source
Actual 2018 Crude Throughput to Refineries for Individual Countries within the ROW Category	multiple		By country, actual crude throughput aggregated for all refineries is provided in the BP Statistical Review. Original data is provided in units of thousand bbl per day.	BP Statistical Review of World Energy 68th edition, 2019 publication.
Volume Fraction of Propane Produced by Refineries in Argentina	0.007	volume fraction	The total actual crude throughput for Argentina in 2018 was used as a data input into the PRELIM model. A representative crude assay was selected for the country. PRELIM estimates the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assay Brazil Lula_BG Group.
Volume Fraction of Propane Produced by Refineries in Chile	0.005	volume fraction	The total actual crude throughput for Chile in 2018 was used as a data input into the PRELIM model. Four representative crude assays were selected for the country. PRELIM was run for each crude scenario to estimate the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection. The arithmetic average for each crude run was used to determine a single volume fraction.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assays Brazil Frade_Chevron, Brazil Lula_BG Group, Brazil Polvo_BP, and Ecuador Oriente_Stratiev; U.S. EIA Energy Profile for Chile.

Table 3-8 (continued). Key data sources - production fractions for propane produced in ROW and imported to California.

Data Input	Value/Unit	Key Notes	Source
Volume Fraction of Propane Produced by Refineries in South Korea	0.005 volume fraction	The total actual crude throughput for South Korea in 2018 was used as a data input into the PRELIM model. Seven representative crude assays were selected for the country. PRELIM was run for each crude scenario to estimate the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection. The arithmetic average for each crude run was used to determine a single volume fraction.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assays Arab Heavy_Stratiev, Arab Light_Stratiev, Arab Medium_Stratiev, Burgan (Wafra)_O&G, Kuwait Eocene_Chevron, Kuwait Export_Stratiev, and Kuwait Ratawi_Chevron; U.S. EIA Energy Profile for South Korea.
Volume Fraction of Propane Produced by Refineries in Norway	0.006 volume fraction	The total actual crude throughput for Norway in 2018 was used as a data input into the PRELIM model. Five representative crude assays were selected for the country. PRELIM was run for each crude scenario to estimate the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection. The arithmetic average for each crude run was used to determine a single volume fraction.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assays Ekofisk_BP, Ekofisk_Chevron, Ekofisk_Statoil, Norway North Sea Skarv_BP, and Norway Oseberg_Statoil.
Volume Fraction of Propane Produced by Refineries in Peru	0.007 volume fraction	The total actual crude throughput for Peru in 2018 was used as a data input into the PRELIM model. A representative crude assay was selected for the country. PRELIM estimates the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assay Brazil Lula_BG Group.

Table 3-8 (continued). Key data sources - production fractions for propane produced in ROW and imported to California.

Data Input	Value/Unit		Key Notes	Source
Volume Fraction of Propane Produced by Refineries in Trinidad and Tobago	0.006	volume fraction	The total actual crude throughput for Trinidad and Tobago in 2018 was used as a data input into the PRELIM model. A representative crude assay was selected for the country. PRELIM estimates the volume percent of propane produced by the collective refinery group based on crude throughput and assay selection.	Petroleum Refinery Life Cycle Inventory Model version 1.3, Dr. Joule Bergerson of the University of Calgary, Crude Assay Nigeria Escravos_Chevron.
Actual 2018 Natural Gas Production for Individual Countries within the ROW Category	multiple		By country, actual natural gas production volume is provided in the BP Statistical Review. Original data is provided in units of billion cubic meters.	BP Statistical Review of World Energy 68th edition, 2019 publication.
Portion of Propane Produced by Natural Gas Plant in Argentina	3.7%	volume percent	Using field gas composition data, a volume percent representing the percent of propane produced from a known given natural gas production operation is determined. Where more than 1 field gas production composition dataset is used, an arithmetic average is used to determine a single, representative value for the country.	Field gas composition data for Miranga Field and Compos Basin sourced from GasEnergia; Latin America LPG Supply & Demand 31st World LGP Forum 2018 - presented by Adrian Calcano Director – Petroleo y Gas Midstream; LPG by Country published by ELGAS (Australia's Primary LPG Gas Supplier).
Portion of Propane Produced by Natural Gas Plant in Chile	0.0%	volume percent	Based on the U.S. EIA energy profile for Chile, propane is not produced by natural gas plant within the region.	U.S. EIA Energy Profile for Chile

Table 3-8 (continued). Key data sources - production fractions for propane produced in ROW and imported to California.

Data Input	Value/Unit		Key Notes	Source
Portion of Propane Produced by Natural Gas Plant in South Korea	10.6%	volume percent	Using field gas composition data, a volume percent representing the percent of propane produced from a known given natural gas production operation is determined. Where more than 1 field gas production composition dataset is used, an arithmetic average is used to determine a single, representative value for the country. South Korea mainly sources natural gas from Saudi Arabia for use in natural gas processing; thus, field gas composition data for fields in this region are deemed representative.	Field gas composition data for fields in Saudi Arabia sourced from Duffuaa; LPG by Country published by ELGAS (Australia's Primary LPG Gas Supplier).
Portion of Propane Produced by Natural Gas Plant in Norway	1.3%	volume percent	Using field gas composition data, a volume percent representing the percent of propane produced from a known given natural gas production operation is determined.	Field gas composition data for Norway sourced from Denys; Gas Composition Transition Agency Report 2013 published by Agentchaps NL Ministerie van Economische Zaken; LPG by Country published by ELGAS (Australia's Primary LPG Gas Supplier).
Portion of Propane Produced by Natural Gas Plant in Peru	0.1%	volume percent	Using field gas composition data, a volume percent representing the percent of propane produced from a known given natural gas production operation is determined.	Field gas composition data for Peru sourced from Denys; Latin America LPG Supply & Demand 31st World LPG Forum 2018 - presented by Adrian Calcaneco Director – Petroleo y Gas Midstream; LPG by Country published by ELGAS (Australia's Primary LPG Gas Supplier).

Table 3-8 (continued). Key data sources - production fractions for propane produced in ROW and imported to California.

Data Input	Value/Unit		Key Notes	Source
Portion of Propane Produced by Natural Gas Plant in Trinidad and Tobago	3.7%	volume percent	Using field gas composition data, a volume percent representing the percent of propane produced from a known given natural gas production operation is determined. Where more than 1 field gas production composition dataset is used, an arithmetic average is used to determine a single, representative value for the country. Field gas composition for fields in Brazil are used as surrogates for the Trinidad and Tobago region.	Field gas composition data for Miranga Field and Compos Basin sourced from GasEnergia; Gas Composition Transition Agency Report 2013 published by Agentchaps NL Ministerie van Economische Zaken; LPG by Country published by ELGAS (Australia's Primary LPG Gas Supplier).

Table 3-9 Key data sources - production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Propane Produced by Refinery from In-State Production	0.73	fraction	The total propane produced by refinery is divided by the total propane produced in California to determine the production fraction. Refer to the Key Sources of Data Tables in Section 2 for a complete list of references regarding this value.	Calculation
Fraction of Propane Produced by Natural Gas Plant from In-State Production	0.27	fraction	The total propane produced by natural gas plant is divided by the total propane produced in California to determine the production fraction. Refer to the Key Sources of Data Tables in Section 2 for a complete list of references regarding this value.	Calculation

Table 3-9 (continued). Key data sources - production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Propane Produced by Refinery and Natural Gas Plant Imported to California from PADD 2	0.00	fraction	Based on distance from the midpoint of Western outer PADD 2 states with propane production capability (Oklahoma, Kansas, North Dakota, and South Dakota) to the midpoint of PADD 5 states, annual average propane price, propane infrastructure, EIA publications, and the in-state propane balance for PADD 5 states, propane exported from PADD 2 to PADD 5 is not sent to California. Therefore, the volume from PADD 2 to PADD 5 is not included in the production ratio for California.	Propane Market Fundamentals for Upper Peninsula Energy Task Force Published November 13, 2019, Warren Wilczewski, Industry Economist.
Fraction of Propane Produced by Refinery Imported to California from PADD 4	0.05	fraction	Calculation - The total volume of propane produced by refinery in PADD 4 is divided by the total propane produced in PADD 4 to calculate the production fraction by refinery. Note the only production methods application for the PADD 4 region are refinery and gas plant (i.e., no oil sand operations).	U.S. EIA, Rocky Mountain (PADD 4) Refinery and Blender Net Production of Propane (Source Key MPARP_R40_2)
Fraction of Propane Produced by Natural Gas Plant Imported to California from PADD 4	0.95	fraction	Calculation - The total volume of propane produced by natural gas plant in PADD 4 is divided by the total propane produced in PADD 4 to calculate the production fraction by gas plant. Note the only production methods application for the PADD 4 region are refinery and gas plant (i.e., no oil sand operations).	U.S. EIA, Rocky Mountain (PADD 4) Field Production of Propane (Source Key M_EPLLPA_FPF_R40_MBBLD)

Table 3-9 (continued). Key data sources - production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Inter-PADD 5 Imports Produced by Refinery	1.00	fraction	As Washington State is the only state within PADD 5 (other than California) to produce propane, all inter-PADD 5 exports to California are estimated to originate from Washington State. Washington State has no natural gas plants or bituminous sands operations— only refineries; thus, all inter-PADD 5 imports to California are produced by refinery.	Estimated portion of known total domestic import value; U.S. EIA Natural Gas Annual Respondent Query System (EIA-757); U.S. EIA Fuel Supply Outlook and Market Overview for Washington State.
Fraction of Canadian Imports Produced by Refinery	0.04	fraction	The fraction of propane production by refinery for Canada is calculated by dividing the total propane refinery sales for the Alberta, British Columbia, Saskatchewan provinces by the total propane sales across all production methods in the same provinces. This value is assumed representative of imports from Canada to PADD 5; and, the PADD 5 production split is assumed equal to that of California.	Calculation
Fraction of Canadian Imports Produced by Natural Gas Plant	0.96	fraction	The fraction of propane production by natural gas plant for Canada is calculated by dividing the total propane natural gas plant sales for the Alberta, British Columbia, Saskatchewan provinces by the total propane sales across all production methods in the same provinces. This value is assumed representative of imports from Canada to PADD 5; and, the PADD 5 production split is assumed equal to that of California.	Calculation

Table 3-9 (continued). Key data sources - production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Canadian Imports Produced by Bituminous Sands	0.00	fraction	While bituminous sands operations produces propane, the entire portion of produced fuel was consumed on-site for 2018.	Alberta Energy Regulator, Canada's Energy Future 2018 Supplement: Natural Gas Liquids Supply and Disposition
Fraction of Imports from ROW - Argentina by Refinery	0.06	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for Argentina. This analysis assumes the country production ratio is equal to the production ratio for imports from Argentina to California.	Calculation
Fraction of Imports from ROW - Chile by Refinery	1.00	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for Chile. This analysis assumes the country production ratio is equal to the production ratio for imports from Chile to California.	Calculation

Table 3-9 (continued). Key data sources - production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Imports from ROW - South Korea by Refinery	0.38	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for South Korea. This analysis assumes the country production ratio is equal to the production ratio for imports from South Korea to California.	Calculation
Fraction of Imports from ROW - Norway by Refinery	0.01	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for Norway. This analysis assumes the country production ratio is equal to the production ratio for imports from Norway to California.	Calculation

Table 3-9 (continued). Key data sources – production fractions for propane consumed in California.

Data Input	Value/Unit		Key Notes	Source
Fraction of Imports from ROW - Peru by Refinery	0.03	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for Peru. This analysis assumes the country production ratio is equal to the production ratio for imports from Peru to California.	Calculation
Fraction of Imports from ROW - Trinidad and Tobago by Refinery	0.027	fraction	The PRELIM based volume fraction of propane produced by the collective refinery group, based on crude throughput and assay selection, was multiplied by throughput to generate the total propane produced by refinery. This total was then divided by the total propane produced in country to obtain the production ratio for Trinidad and Tobago. This analysis assumes the country production ratio is equal to the production ratio for imports from Trinidad and Tobago to California.	Calculation

4. RESULTS

The volume of propane consumed in California in 2018 is calculated using the production ratios shown in Table 3-6. This analysis, shown in Table 4-1, is broken down by production method and region of origin. Using 2018 as a snapshot, 59.5% of each gallon of propane consumed in California is produced by petroleum refineries followed by 40.5% produced by natural gas plants. For 2018, no propane consumed in California was produced by bituminous sand upgrader and fractionator operations.

The production method estimates provided in Table 4-1 is based on the production split as determined by this analysis. However, the production method can vary as discussed in Section 5.

This analysis assumes all volumes of propane imported to California are consumed in California. Also, the total consumption which is used to generate volume totals was determined using a volume balance approach as non-prime supplier consumption is not tracked by the California Energy Commission nor any other agency.

Table 4-1 California propane consumption volumes by production method for 2018.

<i>Parameter</i>	<i>Total Volume</i>	<i>Refinery</i>	<i>Natural Gas Plant</i>
Production, in state	566,496	411,936	154,560
Imports	129,653	16,546	113,106
PADD 2	0	0	0
PADD 4	10,795	574	10,221
other PADD 5 states	9,166	9,166	0
Canada	78,738	2,791	75,946
ROW			
Argentina	2,940	176	2,764
Chile	2,394	2,394	0
Korea, South	2,352	888	1,464
Norway	4,662	55	4,607
Peru	2,352	71	2,281
Trinidad and Tobago	16,254	431	15,823
Exports	107,367	78,074	29,294
other PADDs	0	0	0
other PADD 5 states	772	562	211
Canada	0	0	0
Mexico	106,247	77,259	28,988
ROW	348	253	95
Consumption	588,780	350,407	238,373
<i>Imports + (Production - Exports)</i>			
Imports	129,653	16,546	113,107
Produced in-state	459,128	333,862	125,266
Propane Sources	100%	59.5%	40.5%

Figures 6 and 7 summarize the findings of the volume balance. Figure 6 illustrates the flows of propane used in California as a Sankey diagram where the width of each flow is proportional to its volume. Figure 6 provides a simplified map highlighting the inflow and outflow of California propane and specifying the geographic sources of these flows. Figure 6 is particularly useful for visualizing how much of the propane from each region is sourced from gas plants and petroleum refineries. Roughly half of the propane used in California, 56%, is sourced from petroleum refineries in California. Propane from natural gas plants in California accounts for 21% and the remainder is sourced from imports. Meanwhile, 19% of the propane produced in California is exported to Mexico. A small amount is also exported to other countries; however this amount was so small, ~0.2%, it was omitted from the figure to simplify interpretation. A relatively small amount of propane used in California is sourced from other domestic sources, Washington state and PADD 4, together accounting for about 3%. Imports from Canada account for 13% of consumption while imports from the rest of the world account for 5%.

The diagram serves to underscore the significance of Canadian propane in California's consumption. This is particularly relevant for estimating the sources of propane consumed in California as the propane from Canada is sourced from natural gas plants in a significantly higher share than the propane produced in California.

Figure 6 Sources of propane consumed in California in 2018.

Figure 7 2018 Propane volume balance for California.

5. DATA QUALITY AND BOUNDING ANALYSIS

5.1. Data Quality Assessment

To document key limitations within the process of designating a production method for propane consumed in California, such as gaps in publicly available data, poor data quality, or inconsistent data, each data parameter used to estimate the method of production was evaluated in terms of its data quality. Table 5-1 outlines the qualitative scoring system used to quantify the reliability of each data point used to estimate the results presented in Table 4-1. Based on the qualitative scoring system outlined in Table 5-1, Table 5-2 then assigns grades for each data input used to quantify the origin and production method of propane consumed in California in 2018.

Data Gaps, Assumptions, and Limitations

In quantifying the volume of propane consumed in California and its production method, qualified estimates had to be made for the following parameters:

- The total volume of propane consumed in-state for 2018;
- Production origin for domestically imported propane; and,
- Production method assignment for foreign imported propane.

Table 5-3 highlights the data gaps, assumptions, and emissions impact for each of these parameters.

Table 5-1 Data quality analysis score criteria.

Score	<i>Representativeness to process in terms of:</i>					
	Time	Geographic	Precision	Completeness	Representativeness	Data Clarity
4 - Very Good	Data is within the baseline year, 2018	Data is very localized (i.e., to the state level)	The variability of the dataset is known	Data set is complete with no missing data	Verified data based on measurements (i.e., volume tracking by facility or government agency)	Data is from a verified source and parameters are clearly defined and labeled
3 - Good	Data with less than 1 year's difference from the baseline year	Data is regionally specific (i.e., PADD level)	The variability of the dataset is not known but can be estimated using a verified dataset	Data for no more than one variable is unknown allowing the variable to be solved	Verified data based on assumptions or non-verified data based on measurements	Data is from a verified source, but the dataset is not fully transparent; and, an outside source is used to estimate one or more parameter(s)
2 - Fair	Data with less than 3 years difference from the baseline year	Data is general (i.e., nation-level where state or province level exists but is not available)	The variability of the dataset is not known and is estimated using a non-verified dataset	Data for two or more variables is unknown	Non-verified data based on assumptions or a qualified estimate	Data is from a verified source, but data requires interpretation
1 - Poor	Data with more than 5 years difference from the baseline or the age of data is unknown	Data is from an area that is unknown	No-qualified estimate	Data set is not available	No-qualified estimate	Data is from a non-verified source where data interpretation is not possible
Note: Adapted from International Standard 14044 and Weidema and Wesnaes, 1996						

Table 5-2 Data quality analysis.

Data Parameter	Overall Score	Time	Geographic	Precision	Completeness	Representativeness	Data Clarity
California in-state propane production by refinery	4 - Very Good	4	4	4	4	4	4
California in-state propane production by natural gas plant	3 - Good	4	4	3	3	3	3
Volume of domestic propane imports to California from PADD 2	3 - Good	4	3	2	2	3	3
Volume of domestic propane imports to California from PADD 4	3 - Good	4	3	2	2	3	3
Volume of inter-PADD 5 propane imports to California	3 - Good	4	3	2	2	3	3
Volume of propane imports to California from Canada	4 - Very Good	4	4	4	4	4	4
Volume of propane imports to California from ROW	4 - Very Good	4	4	4	4	4	3
Volume of propane exports from California to other U.S. PADDs	4 - Very Good	4	4	4	4	4	4
Volume of inter-PADD 5 propane exports from California	4 - Very Good	4	4	4	4	4	4
Volume of propane exports from California to Canada	4 - Very Good	4	4	4	4	4	4
Volume of propane exports from California to Mexico	4 - Very Good	4	4	4	4	4	4
Volume of propane exports from California to ROW	4 - Very Good	4	4	4	4	4	4
California propane consumption based on prime supplier sales	4 - Very Good	4	4	4	4	4	4

Table 5-2 (continued). Data quality analysis.

Data Parameter	Overall Score	Time	Geographic	Precision	Completeness	Representativeness	Data Clarity
California propane consumption based on non-prime supplier sales	2 - Fair	4	4	2	2	2	1
Propane production method for PADD 4 imports to California	3 - Good	4	3	3	2	3	3
Propane production method for inter-PADD 5 imports to California	3 - Good	4	3	3	2	3	3
Refinery propane production split for Canadian imports to California	3 - Good	4	3	3	2	3	4
Natural gas plant propane production split for Canadian imports to California	3 - Good	4	3	3	2	3	4
Bitumen sands upgrader and fractionator propane production split for Canadian imports to California	4 – Very Good	4	4	4	4	4	4
Refinery propane production split for ROW imports to California	3 - Good	4	3	2	2	3	2
Natural gas plant propane production split for ROW imports to California	3 - Good	4	3	2	2	3	2
Fraction of propane consumed in California from imports versus in-state production	2 - Fair	4	4	2	1	2	1

Table 5-3 Data gaps, assumptions, and limitations.

Data Parameter	Description of Assumption or Limitation	Potential Impact
Total 2018 Propane Consumption in California	The U.S. EIA only tracks propane consumption from Prime Supplier Sales which is based on survey responses from suppliers who completed Form EIA-782C. ⁵⁹ EIA-782C volumes are designed to measure prime supplier sales into only the local markets of final consumption. By its design, Form EIA-782C volumes exclude sales to any company that is not a local distributor, local retailer, or end user. Additionally, sales to refiners, interstate resellers, importers, traders, and retailers who transport products across state boundaries are excluded (since these are not classified as prime supplier sales). Thus, the consumption dataset available is missing volumes such as those used as a feedstock. To adjust this, a volume balance approach was used which assumed the volume of propane inflow must equal the propane outflow for the state.	The estimated consumption is used in the calculation to estimate the portion of propane consumed by each production method. Without adding to the consumption volume to account for propane consumed from non-prime suppliers, the volume of propane consumed by imports is overinflated. The overall impact to the production method estimate for the California is as follows: 6% for refinery and 9% for natural gas plant.
Production Method for Inter-PADD 5 Imports to California	The CEC tracks domestic rail imports of propane into California; however, the location of origin is not tracked within PADD 5. Based on the location of propane designated rail lines from Washington State to California, it is estimated a portion of the domestic imports to California originate from Washington State. As production via refinery is the only production method within Washington, this analysis designates all imported volume for this category as produced by refinery.	Several scenarios were run to determine the percent change to the overall refinery volume fraction for consumed propane effected by alterations to this parameter. Adjusting this value results in the production method being more weighted to non-refinery production and can reduce the refinery portion by 2.5%.
PADD 4 Imports Production Method	The PADD-wide propane production ratio was assigned to imports from PADD 4 to California as the exact source of propane (i.e., a single refinery or natural gas plant or combination of) was not known.	Several scenarios were run to determine the percent change to the overall volume fractions for consumed propane effected by alterations to this parameter. Adjusting this value to assume the volume imported originates entirely from a refinery or refineries, increases the refinery production by up to 2.9%.

⁵⁹ U.S. EIA Propane All Sales/Deliveries by Prime Supplier (Source Keys C900050041, C900050061, C900050321, C900050411, and C900050531).

Table 5-3 (continued). Data gaps, assumptions, and limitations.

Data Parameter	Description of Assumption or Limitation	Potential Impact
Assigning of Production Method for Propane ROW Imports to California	This analysis distributes the volume of propane imported to California from ROW to production by refinery and natural gas plant. However, the volumes of propane imported from ROW are small enough that it becomes technically feasible that the volume could have originated from a single or group of refineries. Similarly, all volumes could have originated from a single or group of natural gas plants.	Adjusting the imported volumes from ROW to assume the propane originates all from refineries changes the refinery baseline estimate by 2%. The potential adjustment for natural gas plant for this scenario as compared to the baseline is less than 1%.

5.2. Bounding Analysis

To evaluate the impact of key study assumptions on the results and assess data uncertainty, a bounding analysis was conducted to determine both the upper and lower bound for the propane production split for propane consumed in California. The following scenarios are assessed with individual results presented in Table 5-4:

PADD 4 Imports

In the baseline study results, the share of propane production by refinery and natural gas sources for the entire PADD 4 area (95% from natural gas plants) was applied to the volume imported from PADD 4 to Canada. Since the exact source of propane (i.e., a single refinery or natural gas plant or combination of) is not known and based on the magnitude of the volume imported, it is technically possible that the imported volume could be supplied entirely by refinery. In this scenario, the volume of propane from PADD 4 was assigned entirely to refinery sources. The result was a 2.9% increase in the overall refinery share and a lowering of the natural gas share by 4.3% for an overall ratio of 60% refinery, 40% natural gas plant, and 0% bituminous sands.

Table 5-4 Results for bounding analysis scenarios.

<i>Scenario Description</i>	<i>Refinery</i>	<i>Natural Gas Plant</i>
0. Baseline	60%	40%
1. All imports from PADD 4 are from refineries	61%	39%
<i>% difference</i>	<i>2.9%</i>	<i>-4.3%</i>
2a. All imports from Canada are from refineries	72%	28%
<i>% difference</i>	<i>21%</i>	<i>-32%</i>
2b. All imports from Canada are from natural gas plants	59%	41%
<i>% difference</i>	<i>-0.8%</i>	<i>1.2%</i>
3a. All ROW imports are from Refinery	64%	36%
<i>% difference</i>	<i>7.7%</i>	<i>-11%</i>
3b. All ROW imports are from natural gas plants *	59%	41%
<i>% difference</i>	<i>-0.5%</i>	<i>0.8%</i>

* For 3b, all imports are from natural gas plants except for imports from Chile which has no plants, only refineries.

Canadian Imports

To determine the propane production split across Alberta, British Columbia, and Saskatchewan provinces, propane sales by refinery and natural gas plants were divided by the total sales for all production types in those same provinces. It was assumed that the shares of methods used to produce the propane imported to California from Canada are equal to their shares of total propane production in those provinces. To put bounds on the effect of this assumption, two cases were estimated where the total volume of propane imported to California from Canada was separately assigned entirely to refineries and then natural gas plants. Because the production shares for the imports from Canada are skewed so heavily toward production by natural gas plants, the effect of this analysis was small when shifting the source of Canadian propane entirely to natural gas plants, resulting in a California consumption mix of 59% from refineries and 41% from natural gas plants. However, when the calculation is performed for all Californian imports of Canadian propane sourced from refineries, the contribution of propane from refineries in the California consumption mix increases to 72% from refineries and 28% from natural gas plants. It should be noted that this scenario is unlikely given the prominence of propane from natural gas

plants in the mix for the Canadian provinces from which California is most likely to import propane. However, it also highlights the potential value of collecting additional data regarding the production method used for propane imported to the California market.

ROW Imports

For the baseline results, the PRELIM model was used to determine the volume fraction of propane produced by refineries, and field gas composition data was used to determine the fraction produced by natural gas plants. However, the volumes of propane imported from ROW was small enough that it is technically feasible that the volume could have originated entirely from one or more refineries or one or more natural gas plants. To determine the possible data range, the volume of propane from ROW was assigned entirely to refinery sources, then entirely to natural gas plants (except for Chile, which has only refinery sources of propane). The result was that the production shares vary only moderately with an overall ratio of 60-64% for the refinery, and a negligible difference for natural gas (approximately 0.5%).

As several of these scenarios could exist simultaneously and amplify the influence on the study results, an evaluation of nine separate cases of overlapping scenarios was conducted to establish a minimum and maximum range for each production share, i.e. to establish the combined upper and lower bound of data values. These ranges along with the study baseline results are shown in Figure 8. The aggregated study results show potential variation for production by refinery from 57 – 79% and for the natural gas plant by 21 – 43%. As no propane is consumed in California produced by bituminous sand operations, the best estimate is 0% with no variation for 2018.

Figure 8. Combined bounding analysis scenarios – full (extreme) range of production method for propane consumed in California.

6. CONCLUSIONS

This study documents the sources of propane consumed in California for a baseline year of 2018. As presented in the preceding sections, we estimate that propane consumed in California in 2018 is sourced 59.5% from petroleum refineries and 40.5% from natural gas plants by volume. We estimate that none of the propane consumed in California is sourced from bitumen upgrader and off-gas fractionator operations.

While the amount of propane produced in California nearly matches the amount consumed, a significant amount of propane is exported from California, and a nearly equal amount is imported to the state to meet demand. The volume of propane produced in California is equal to 96% of the volume consumed in the state. California exports 19% of the propane produced and therefore 22% of the demand in the state is met with imported propane. While most of these exports leave through California's southern border, nearly all the exported amount destined for Mexico, and a substantial share of the imports enter from Canada in the north, Canada is the supplier of 61% of propane imports to California.

The shares of production methods for the propane consumed in California differs from the shares of production methods for the propane produced in the state, due to significant propane trade. While 73% of the propane produced in California is sourced from petroleum refining operations, 87% of the propane imported for consumption in California is sourced from natural gas plants. This difference could have a significant effect on the calculation of upstream, supply chain greenhouse gas emissions of propane consumed in California as previous studies have shown the life cycle greenhouse gas emissions of propane produced by natural gas plants to be lower than those for propane produced by petroleum refineries.

The estimation method used in this study, based on publicly-available datasets, a volume balance approach for trade flows, and regional production statistics could continue to be used to update the results as propane supply and demand evolve. The results of this study are suitable for incorporation in an assessment of the life cycle carbon intensity of propane used as a transportation fuel in California in 2018. If demand for propane as a transportation fuel in California increases, it would affect the market and propane sources used in the state. Other market effects, both local and global, as well as changes in infrastructure, the global cost of crude and natural gas, production technologies, technically recoverable resources, geopolitical events, natural forces, and climate change will change the production landscape and contribute to changes in the sources of propane used in California in the future. Of particular concern is how the regulatory climate may change in terms of additional control measures, the addition of tariffs and/or incentives, and initiatives to reduce the presence of refineries in certain locations. In order to adequately assess the carbon intensity applied to fuel consumption in the California transportation market, the balance of production should be reviewed and updated on a regular basis. Therefore, if these estimates are adopted for estimating the supply chain carbon intensity of propane in a regulatory context, it is recommended that a suitable interval be set for their re-evaluation in future years.

Further, the government institutions with the mission to compile relevant data should be urged to disaggregate the statistics provided to the state and province level to improve the resolution and reduce the uncertainty of subsequent estimates.

If demand increases and/or in-state propane production declines, the California market could become increasingly reliant on imported propane. Going forward, the geographic origin of imported propane could become a driving factor in supplier selections, where those making decisions seek to reduce the

carbon intensity associated with the fuel consumed in their operations or region. As an illustration of how this could affect the outcomes associated with such changes, consider that in 2018 California imported propane from South Korea. According to the U.S. EIA, South Korea has a large oil refining sector, but relies almost entirely on crude oil imports to supply its refineries. Almost half of the crude oil imported to South Korea in 2018 was sourced from the Middle East (primarily from Saudi Arabia and Kuwait).⁶⁰ As such, a finished product arriving in California from South Korea bears the added transportation-related carbon intensity of that product – accounting for the transport of raw material from the Middle East to Korea, plus the additional transport from South Korea to California. While these supply chain considerations should be evaluated for all imported propane, it is also important to ensure the carbon intensity factors for other transportation fuels have properly weighted the origin of raw materials as well as the finished product so that a fair comparison of alternative fuels can be conducted.

If these results are used in the context of measures to mitigate greenhouse gas emissions, the effect of the measures on both local and global greenhouse gas emissions should be taken into account. Selectively increasing demand for low carbon propane in one region while not considering the fate of higher carbon propane sources could result in carbon leakage whereby the net effect of the mitigation measure on greenhouse gas emissions is negligible as the higher carbon propane is just used elsewhere. This situation is complicated for propane by the fact that it is co-produced, and arguably a by-product of, the petroleum refining and natural gas plant operations by which it is produced. The example above for South Korea provides another relevant case point. If a policy results in a decrease in natural gas and/or crude oil production, imported fuels may fill the gap until technological advances in the energy sector occur, i.e. alternative energy. By taking these points into consideration California would be poised to evaluate the relative merits of fuel produced in-state within its regulatory oversight and with minimal travel distance to consumers compared with imports, which if not managed could be sourced from regions with less environmental oversight than California and the U.S.

⁶⁰ U.S. EIA energy profile for South Korea. Source: <https://www.eia.gov/international/analysis/country/KOR>.

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Appendix A – Refineries and Natural Gas Plants in PADD 5

Table A.1. List of Petroleum Refineries within Petroleum Administration for Defense District Five West Coast (PADD 5) ^{(10), (11)}

As of December 31, 2018.

Petroleum Administration for Defense District	Site Name	Owner	County	State	Total Crude Capacity (barrel per calendar day)	Footnote(s)
PADD 5, West Coast	Carson/Wilmington	Marathon Petroleum Corp	Los Angeles	California	363,000	3, 4
	El Segundo	Chevron U.S.A. Inc	Los Angeles	California	269,000	1
	Richmond	Chevron U.S.A. Inc	Contra Costa	California	257,000	2
	Martinez (Golden Eagle)	Marathon Petroleum Corp	Contra Costa	California	161,500	3
	Martinez	Shell Oil Products US	Contra Costa	California	156,400	3
	Torrance	PBF Energy	Los Angeles	California	155,000	5, 6
	Benicia	Valero Energy	Solano	California	145,000	3
	Wilmington	Phillips 66 Company	Los Angeles	California	139,000	3
	Wilmington	Valero Energy	Los Angeles	California	135,000	8
	Rodeo	Phillips 66 Company	Contra Costa	California	120,200	3
	Bakersfield	Kern Oil & Refining Company	Kern	California	26,000	3
	Bakersfield	San Joaquin Refining Company Inc	Kern	California	15,000	3
	Santa Maria	Greka Energy	Santa Barbara	California	9,500	3
	South Gate Refinery	Lunday Thagard (World Oil)	Los Angeles	California	8,500	3
	Valero Wilmington Asphalt	Valero Energy	Los Angeles	California	6,300	3
	Paramount	World Energy	Los Angeles	California	Idle	7
	Cherry Point	BP	Whatcom	Washington	242,000	9
	Anacortes	Shell Oil Products US	Skagit	Washington	145,000	9
	Anacortes	Marathon Petroleum Corp	Skagit	Washington	119,000	9
	Ferndale	Phillips 66 Company	Whatcom	Washington	105,000	9
	Tacoma	U.S. Oil and Refining Co	Pierce	Washington	40,700	9
	Ely/Eagle Springs Refinery	Foreland Refining Corporation	White Pine	Nevada	2,000	9

Notes:

- (1) Capacity provided by the U.S. Energy Information Administration, California Energy Commission Transportation Fuels Data and confirmed in the Chevron 2018 supplement to the annual report. Sources: https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html; <https://www.chevron.com/-/media/shared-media/documents/annual-report-supplement-2018.pdf>.
- (2) Capacity provided by the U.S. Energy Information Administration, California Energy Commission Transportation Fuels Data and the Chevron 2018 supplement to the annual report conflicted. The capacity shown, 257,000 bpd, is as listed in the Chevron 2018 supplement to the annual report. Sources: https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html; <https://www.chevron.com/-/media/shared-media/documents/annual-report-supplement-2018.pdf>.
- (3) Crude processing capacity is provided by the U.S. Energy Information Administration, California Energy Commission Transportation Fuels Data. Source: https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html.
- (4) Carson and Wilmington refineries are reported as a single entity.
- (5) Exxon Mobil sold to New Jersey-based PBF Energy in 2016.
- (6) The PBF Energy Torrance Refinery has a name plate capacity of 155,000 bpd based on the company's profile; this value conflicts with that listed in the U.S. Energy Information Administration, California Energy Commission Transportation Fuels Data. The value of 155,000 bpd is used as it reflects company published data sets. Sources: <https://www.pbfenergy.com/refineries#torrance>; https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html.
- (7) The Paramount Refinery previously owned by Delek US sold to Boston-based biofuel producer World Energy in 2018 and from 2018 to present, refinery operations are idle. Source: https://ww2.energy.ca.gov/almanac/petroleum_data/refinery_history.html.
- (8) Capacity provided by the U.S. Energy Information Administration, California Energy Commission Transportation Fuels Data and the Valero Wilmington 10-K annual report conflicted. The capacity shown, 135,000 bpd, is as listed in the Valero financial report provided via US Form 10-K. Sources: https://ww2.energy.ca.gov/almanac/petroleum_data/refineries.html; http://www.annualreports.com/HostedData/AnnualReports/PDF/NYSE_VLO_2018.pdf.
- (9) Capacity obtained from the AFPM United States Refining and Storage Capacity Report. Source: <https://www.afpm.org/system/files/attachments/AFPM-Capacity-Report-2019.pdf>.
- (10) Table above does not include Alon USA Energy Inc's Bakersfield Refinery as the plant is currently non-operational. Additionally, the 2014 proposal to ship Bakken crude to the now-closed refinery in Bakersfield that would be reopened to process the oil was officially rejected by Kern County in late 2018/early 2019.
- (11) Arizona, Oregon, have no refining capacity.

Table A.2. List of Natural Gas Processing Plants within Petroleum Administration for Defense District Five West Coast (PADD 5)

As of December 31, 2018.

Petroleum Administration for Defense District	Site Name	Owner	County	State	Production Capacity (MMscf/day)	Foot-note
PADD 5, West Coast	California-San Joaquin Basin	California Resources Corporation	Kern	California	225	1
	McKittrick 17Z Plant	Chevron	Kern	California	80	1, 7
	Las Flores Canyon, POPCO	ExxonMobil Production Company	Santa Barbara	California	30	5
	Crestwood	Crestwood Midstream Partners	KERN	California	24	1
	Belridge Gas Plant	Aera Energy	Kern	California	25	2, 3
	Santa Clara Valley Gas Plant	Vintage Pipeline	Ventura	California	17	1
	Lompoc Oil & Gas Plant	Freeport-McMoRan Oil & Gas - 100%	Santa Barbara	California	15	1
	Ventura Gas Plant 7	Aera Energy	Ventura	California	12	1
	Signal Hill West Unit Gas Plant	Signal Hill Petroleum, Inc.	Los Angeles	California	4	1
	Greeley Gas Plant	Crimson Resource Management Corp	Kern	California	1	1
	South Coles Levee Gas Plant	Central Resources, Inc.	Kern	California	1	4
	Total:				434	6

** Arizona, Nevada, Oregon, and Washington have no natural gas processing plants in operation in 2018.*

Notes:

(1) Natural gas plant listing including plant capacity obtained from Form EIA-757 Schedule A data, current Form EIA-64A data, and publicly available company information. Copy of data set available: <https://www.eia.gov/naturalgas/ngqs/#?report=RP9&year1=2017&year2=2017&company=Name>.

(2) Belridge natural gas processing listing based on company information. Source: <https://www.aeraenergy.com/operations/belridge/>.

(3) Belridge natural gas processing capacity estimated based on actual flow data provided by EIA and publicly available company information. Source: https://www.grac.org/media/files/files/c7f39f35/4.4_Morris.pdf; and, <https://www.eia.gov/naturalgas/ngqs/#?report=RP9&year1=2017&year2=2017&company=Name>.

(4) The South Coles Levee Gas Plant has decreased operations starting in 2018 and continuing to present. Based on well activity, it is estimated the 2018 plant capacity is approximately 1 MMscf/day.

(5) Capacity for Las Flores Canyon, POPCO Gas Plant is based on Permit to Operate 8092-R9 and Title V Part 70 Permit Number 8092. Note Phase 2 to expand capacity was never constructed.

(6) Independent verification used to justify total capacity of 434 MMscf/day was obtained from 2017 EIA report (last time capacities were released from EIA). Source: https://www.eia.gov/naturalgas/annual/pdf/appendix_a.pdf. publicly available company information was searched as supplement to data verification. This public search included:

6a) ArcGIS natural gas processing plant maps -

<https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=7b96111b7bed4420bfe57e3696ea70f3&layerId=0>

6b) Shale Map Explorer - <https://www.shalexp.com/>

6c) Open Canada North America Natural Gas Processing Source Maps - <https://open.canada.ca/data/en/dataset/636b9550-3700-4e66-8259-5cfc8159a784>

(7) Chevron McKittrick 17Z Plant is now closed.

Notes on Sites Not Included in Table Above:

(1) Linn Energy underwent restructuring in 2017 and from 2018 to present has no natural gas processing capacity in California.

(2) In 2017, Venoco's Carpinteria Gas Plant and Ellwood Onshore Facility shut-in operations due to bankruptcy. Source: http://www.coastalview.com/news/goodbye-oil-processing-carpinteria-oil-plant-to-be-decommissioned/article_b8432fe8-ceed-11e7-b070-23c9cd7603f5.html.

(3) Based on Permit to Operate 5651-R6 and Title V Part 70 Permit 5651, Exxon's Las Flores Canyon, SGTP site leases natural gas processing operations to the POPCO site. As such, no capacity is listed for the Las Flores Canyon, SGTP site separately.

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Appendix B – Refineries in Canada

Table B.1. List of Petroleum Refineries Operating in Canada.

#	Site Name ⁽¹⁾	Owner	Province	Province	Capacity (bbl/day)
1	North Atlantic Refinery	North Atlantic Refining	Newfoundland & Labrador	NL	130,000
2	Irving Oil Refinery	Irving Oil	New Brunswick	NB	300,000
3	Montreal Refinery	Suncor Energy	Quebec	QC	137,000
4	Jean-Gaulin Refinery	Valero (Ultramar)	Quebec	QC	235,000
5	Nanticoke Refinery	Imperial Oil	Ontario	ON	112,000
6	Sarnia Refinery	Imperial Oil	Ontario	ON	121,000
7	Corunna Refinery	Shell Canada	Ontario	ON	75,000
8	Clarkson Refinery	Hollyfrontier	Ontario	ON	15,600
9	Sarnia Refinery	Suncor Energy	Ontario	ON	85,000
10	Co-op Refinery	FCL	Saskatchewan	SK	135,000
11	Moose Jaw Refinery	Gibson Energy	Saskatchewan	SK	22,000
12	Strathcona Refinery	Imperial Oil	Alberta	AB	191,000
13	Scotford Refinery	Shell Canada	Alberta	AB	114,000
14	Edmonton Refinery	Suncor Energy	Alberta	AB	142,000
15	Lloydminster Refinery	Husky Energy	Alberta	AB	30,000
16	Burnaby Refinery	Parkland Fuel ⁽²⁾	British Columbia	BC	55,000
17	Prince George Refinery	Tidewater Midstream ⁽³⁾	British Columbia	BC	12,000
Total Canadian Refining Capacity:					1,911,600
<p>(1) Refinery listed obtained from the Canadian National Energy Board and the Canadian Association of Petroleum Producers (CAPP) Crude Oil Forecast, Markets, and Transportation 2019 Report. Source: https://www.capp.ca/resources/crude-oil-forecast/; and, https://www.nrcan.gc.ca/energy/energy-sources-distribution/refining-sector-canada/4541.</p> <p>(2) Purchased from Chevron in Q3 of 2017.</p> <p>(3) Purchased from Husky Energy in November 2019.</p>

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Appendix C – Propane Production Ratio for Canada Detailed Calculation

Table C.1. Total Propane Sales for Alberta, British Columbia, and Saskatchewan, Canadian Provinces to All Destinations.

Province	Propane Sales by Refinery	Propane Sales by Bituminous Sands	Propane Sales by Natural Gas Plant
	cubic meters	cubic meters	cubic meters
Alberta	410,949	0	11,132,500
British Columbia	0	0	1,971,413
Saskatchewan	90,513	0	540,456
Total:	501,462	0	13,644,370
Percent of Total Sales to All Destinations:	3.54%	0.00%	96.46%
Province	Propane Sales by Refinery	Propane Sales by Bituminous Sands	Propane Sales by Natural Gas Plant
	thousand gallons	thousand gallons	thousand gallons
Alberta	108,561	0	2,940,895
British Columbia	0	0	520,792
Saskatchewan	23,911	0	142,773
Total:	132,472	0	3,604,460
Percent of Total Sales to All Destinations:	3.54%	0.00%	96.46%
Propane Sales from Alberta Bituminous Sands to PADD 5.			
Province(s)	Propane Sales by Bituminous Sands	Propane Sales by Bituminous Sands	Total Propane Imported to PADD 5
	cubic meters	thousand gallons	thousand gallons
Alberta	0	0	524,792
Total Propane Sales from Alberta, British Columbia, and Saskatchewan Provinces to All Destinations.			
Province	Propane Sales by Refinery	Propane Sales by Natural Gas Plant	
	cubic meters	cubic meters	
Alberta	410,949	11,132,500	
British Columbia	0	1,971,413	
Saskatchewan	90,513	540,456	
Total:	501,462	13,644,370	
Percent of Total Sales <u>if Propane is from Refinery or NG Plant Only</u> :	3.54%	96.46%	

Table C.1 (continued). Total Propane Sales for Alberta, British Columbia, and Saskatchewan, Canadian Provinces to All Destinations.

Estimated Refinery Propane Sales from Alberta, British Columbia, and Saskatchewan Provinces to PADD 5.		
Province(s)	Imported Total (Refinery + NG Plant Portion)	Propane Sales by Refinery
	thousand gallons	thousand gallons
Alberta, British Columbia, Saskatchewan	524,792	18,604
Estimated NG Plant Propane Sales from Alberta, British Columbia, and Saskatchewan Provinces to PADD 5.		
Province(s)	Imported Total (Refinery + NG Plant Portion)	Propane Sales by NG Plant
	thousand gallons	thousand gallons
Alberta, British Columbia, Saskatchewan	524,792	506,189
	PADD 5 (thousand gallons)	California (thousand gallons)
Total Imports from Canada	524,792	78,738
Refinery Total	18,604	2,791
Natural Gas Production Total	506,189	75,946
Bituminous Sands Total	0	0
Refinery Fraction	0.04	0.04
Natural Gas Production Fraction	0.96	0.96
Bituminous Sands Fraction	0.00	0.00
Conversions: 1 m3 equals 264.172 U.S. gallons: 264.172 thousand gallon to gallon: 1,000

SOURCES OF PROPANE CONSUMED IN CALIFORNIA

Appendix D – Propane Production Ratio for Rest of World Detailed Calculation

Table D.1. California Propane Imports from Rest of World - 2018 Basis.

	Actual Refining Throughput	Volume Fraction of Propane Production based on the Petroleum Refinery Life Cycle Inventory Model	Estimated Propane Produced by Refinery	Estimated Propane Produced by Refinery	
	(thousand bbl per day)	(fraction)	(thousand bbl per day)	(thousand gallons in 2018)	
Argentina	470	0.01	3.24	49,715.19	
Chile	172	0.00	0.84	12,920.12	
Korea, South	3,030	0.00	13.94	213,669.54	
Norway	286	0.01	1.77	27,183.16	
Peru	209	0.01	1.44	22,107.39	
Trinidad and Tobago	99	0.01	0.54	8,347.19	
Raw Value					
	Actual Natural Gas Production	Volume of Propane Produced from Natural Gas Processing Based on Field Production Stream Data	Estimated Propane Produced by Natural Gas Plant		
	(billion m ³)	(volume percent)	(thousand gallons in 2018)		
Argentina	39	3.7%	781,814.36		
Chile	0	0.0%	0.00		
Korea, South	0	10.6%	352,582.95		
Norway	121	1.3%	2,284,124.32		
Peru	13	0.1%	705,165.90		
Trinidad and Tobago	34	3.7%	306,593.87		
	Total Propane Production	Estimated Propane Produced by Refinery	Fraction of Propane Produced by Refinery	Estimated Propane Produced by Natural Gas Plant	Fraction of Propane Produced by NG Plant
	(thousand gallons in 2018)	(thousand gallons in 2018)	(fraction)	(thousand gallons in 2018)	(fraction)
Argentina	831,530	49,715	0.06	781,814	0.94
Chile	12,920	12,920	1.00	0	0.00
Korea, South	566,252	213,670	0.38	352,583	0.62
Norway	2,311,307	27,183	0.01	2,284,124	0.99
Peru	727,273	22,107	0.03	705,166	0.97
Trinidad and Tobago	314,941	8,347	0.03	306,594	0.97

Table D.2. Oil field natural gas composition by country.

				3/23/2020	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	CARBON DIOXIDE	HYDROGEN	HYDROGEN SULFIDE	NITROGEN	Surrogate C2
Stream Description				Formula	C1H4	C2H6	C3H8	C4H10	C5H12	CO2	H2	H2S	N2	C2H6
				CAS #	00074-82-8	00074-84-0	00074-98-6	00106-97-8	00109-66-0	00124-38-9	01333-74-0	07783-06-4	07727-37-9	00074-84-0
				Default Order #	1	2	3	4	5	6	7	8	9	
				MW (lb/lb-mol)	16.04	30.07	44.10	58.12	72.15	44.01	2.02	34.08	28.01	30.07
				Gas Density (lb/ft3)	0.0416	0.0784	0.1160	0.1551	0.1897	0.1144	0.0052	0.0888	0.0725	0.0784
Country	Product	Field Name	Source	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %
US	Natural Gas	Western Colorado	Jechura	100.00	33.10	0.82	0.82	0.80	0.82	47.06	-	-	16.58	
US	Natural Gas	Kansas	Jechura	100.00	74.96	-	3.43	1.50	1.52	-	-	-	18.58	
US	Natural Gas	Barnett Shale	Jechura	100.00	84.11	7.21	1.43	-	-	2.89	-	-	4.36	
US	Natural Gas	Marcellus Shale	Jechura	100.00	84.84	11.10	2.57	-	-	1.49	-	-	-	
US	Natural Gas	Alaska	Denys	100.00	99.70	0.09	0.03	0.01	-	-	-	-	0.17	
US	Natural Gas	Appalachian Basin	Burruss	100.00	85.22	6.68	2.82	1.13	0.37	-	0.00	-	3.79	
US	Natural Gas	Appalachian Basin	Burruss	100.00	90.35	4.73	1.46	0.55	0.21	0.01	0.00	-	2.68	
US	Natural Gas		Jechura	-										
US	Natural Gas		Jechura	-										
US	Average Gas		(FINAL)	100.00	78.90	4.38	1.79	0.57	0.42	7.35	0.00	-	6.60	-
Brazil	Natural Gas	Miranga	GasEnergia	100.00	85.82	8.25	3.03	1.29	0.44	0.64	-	-	0.53	
Brazil	Natural Gas	Compos Basin	GasEnergia	100.00	84.90	7.59	4.40	1.91	0.24	0.32	-	-	0.65	
Brazil	Average Gas		(FINAL)	100.00	85.36	5.46	3.71	1.60	0.34	0.48	-	-	0.59	2.46

Table D.2 (continued). Oil field natural gas composition by country.

				3/23/2020	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	CARBON DIOXIDE	HYDROGEN	HYDROGEN SULFIDE	NITROGEN	Surrogate C2
Stream Description				Formula	C1H4	C2H6	C3H8	C4H10	C5H12	CO2	H2	H2S	N2	C2H6
				CAS #	00074-82-8	00074-84-0	00074-98-6	00106-97-8	00109-66-0	00124-38-9	01333-74-0	07783-06-4	07727-37-9	00074-84-0
				Default Order #	1	2	3	4	5	6	7	8	9	
				MW (lb/lb-mol)	16.04	30.07	44.10	58.12	72.15	44.01	2.02	34.08	28.01	30.07
				Gas Density (lb/ft3)	0.0416	0.0784	0.1160	0.1551	0.1897	0.1144	0.0052	0.0888	0.0725	0.0784
Country	Product	Field Name	Source	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %
Boliva (to Brazil)	Natural Gas	Bolivia	Gaulberto	97.89	89.10	5.83	1.88	0.74	0.34	-	-	-	-	
	Natural Gas			-										
Boliva (to Brazil)	Average Gas		(FINAL)	100.00	89.10	5.83	1.88	0.74	0.34	-	-	-	-	2.11
Canada	Natural Gas	Alberta Oil Sands	Jechura	100.00	72.49	9.10	3.47	4.45	3.47	1.40	-	2.80	2.82	
Canada	Natural Gas	Western Canada		100.00	94.93	2.49	0.20	0.06	0.02	0.70	-	-	1.60	
Canada	Average Gas		(FINAL)	100.00	83.71	5.79	1.83	2.25	1.75	1.05	-	1.40	2.21	(0.00)
Norway	Natural Gas	Norway	Denys	100.00	92.09	5.72	1.29	0.44	-	-	-	-	0.46	
Norway	Natural Gas			-										
Norway	Average Gas		(FINAL)	100.00	92.09	5.72	1.29	0.44	-	-	-	-	0.46	-
Peru	Natural Gas	Peru	Denys	100.00	89.56	10.26	0.10	0.01	-	-	-	-	0.07	-
Peru	Natural Gas			-										
Peru	Average Gas		(FINAL)	100.00	89.56	10.26	0.10	0.01	-	-	-	-	0.07	0.00

Table D.2 (continued). Oil field natural gas composition by country.

				3/23/2020	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	CARBON DIOXIDE	HYDROGEN	HYDROGEN SULFIDE	NITROGEN	Surrogate C2
Stream Description				Formula	C1H4	C2H6	C3H8	C4H10	C5H12	CO2	H2	H2S	N2	C2H6
				CAS #	00074-82-8	00074-84-0	00074-98-6	00106-97-8	00109-66-0	00124-38-9	01333-74-0	07783-06-4	07727-37-9	00074-84-0
				Default Order #	1	2	3	4	5	6	7	8	9	
				MW (lb/lb-mol)	16.04	30.07	44.10	58.12	72.15	44.01	2.02	34.08	28.01	30.07
				Gas Density (lb/ft3)	0.0416	0.0784	0.1160	0.1551	0.1897	0.1144	0.0052	0.0888	0.0725	0.0784
Country	Product	Field Name	Source	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %
Saudi Arabia	Natural Gas	Ain Dar	Duffuaa	100.00	46.12	19.02	11.59	4.39	2.97	11.88	-	3.72	0.30	
Saudi Arabia	Natural Gas	Haradh	Duffuaa	100.00	56.08	18.29	9.91	3.15	1.56	9.44	-	1.17	0.39	
Saudi Arabia	Natural Gas	Uthmaniya h	Duffuaa	100.00	50.05	18.83	11.54	4.49	2.72	10.30	-	1.78	0.28	
Saudi Arabia	Natural Gas	Fazran	Duffuaa	100.00	54.93	19.91	10.40	3.56	1.82	7.46	-	1.80	0.11	
Saudi Arabia	Natural Gas	Shedgum	Duffuaa	100.00	49.60	18.14	11.17	4.40	3.10	9.90	-	2.45	1.24	
Saudi Arabia	Natural Gas	Hawiyah	Duffuaa	100.00	56.90	17.37	9.10	2.93	1.48	10.91	-	1.30	-	
Saudi Arabia	Natural Gas	Abqaiq	Duffuaa	100.00	60.78	16.37	6.87	1.99	0.79	9.37	-	3.22	0.60	
Saudi Arabia	Natural Gas	Abu Hadriyah	Duffuaa	100.00	38.62	17.86	15.49	9.17	9.02	4.09	-	5.13	0.61	
Saudi Arabia	Natural Gas	Abu Safah	Duffuaa	100.00	49.57	19.46	12.20	4.47	1.81	6.90	-	2.02	3.58	
Saudi Arabia	Natural Gas	Berri	Duffuaa	100.00	53.09	19.17	8.35	2.39	1.05	7.98	-	7.73	0.24	
Saudi Arabia	Natural Gas	Dammam	Duffuaa	100.00	69.52	3.00	1.49	1.05	1.21	10.05	-	1.65	12.02	

Table D.2 (continued). Oil field natural gas composition by country.

Oil Field Natural Gas Composition Data By Country				3/23/2020	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	CARBON DIOXIDE	HYDROGEN	HYDROGEN SULFIDE	NITROGEN	Surrogate C2
Stream Description				Formula	C1H4	C2H6	C3H8	C4H10	C5H12	CO2	H2	H2S	N2	C2H6
				CAS #	00074-82-8	00074-84-0	00074-98-6	00106-97-8	00109-66-0	00124-38-9	01333-74-0	07783-06-4	07727-37-9	00074-84-0
				Default Order #	1	2	3	4	5	6	7	8	9	
				MW (lb/lb-mol)	16.04	30.07	44.10	58.12	72.15	44.01	2.02	34.08	28.01	30.07
				Gas Density (lb/ft3)	0.0416	0.0784	0.1160	0.1551	0.1897	0.1144	0.0052	0.0888	0.0725	0.0784
Country	Product	Field Name	Source	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %	Vol %
Saudi Arabia	Natural Gas	Harmaliyah	Duffuaa	100.00	47.84	19.46	10.62	3.90	2.47	9.40	-	6.23	0.08	
Saudi Arabia	Natural Gas	Khurais	Duffuaa	100.00	42.18	23.76	17.71	6.58	3.76	5.27	-	0.23	0.50	
Saudi Arabia	Natural Gas	Khursaniyah	Duffuaa	100.00	41.88	20.40	15.86	6.84	4.56	6.42	-	3.78	0.27	
Saudi Arabia	Natural Gas	Manifah	Duffuaa	100.00	28.69	18.22	16.48	5.96	3.09	11.48	-	16.08	-	
Saudi Arabia	Natural Gas	Marjan	Duffuaa	100.00	80.62	10.88	4.44	1.54	0.72	1.47	-	-	0.32	
Saudi Arabia	Natural Gas	Qatif	Duffuaa	100.00	34.64	15.50	11.53	4.14	2.14	17.55	-	14.10	0.39	
Saudi Arabia	Natural Gas	Safaniyah	Duffuaa	100.00	49.08	23.36	11.31	8.60	4.27	1.88	-	-	1.50	
Saudi Arabia	Natural Gas	Zuluf	Duffuaa	100.00	78.98	11.99	5.51	1.07	0.90	1.07	-	-	0.48	
Saudi Arabia	Average Gas		(FINAL)	100.00	52.06	17.42	10.61	4.24	2.60	8.04	-	3.81	1.21	(0.00)

This data was provided as volume percent

Table D.3. Propane supply calculations for California sources of imports from rest of world.

Country	Actual Annual Natural Gas Production	[Conversion]	Actual Annual Natural Gas Production	Reference EIA 2017 Natural Gas Production (dry)	Volume of Propane Produced from Natural Gas Processing Based on Field Production Stream Data	Calculated Annual Propane Produced (gas)	Calculated Annual Propane Produced (gas)	Density of Propane (gas)
-	(b cu m)	(cu ft/cu m)	(b cu ft)	(b cu ft)	(Volume Percent)	(b cu ft)	(cu ft)	(lb/cu ft)
Argentina	39.40	35.32	1,391	1,445	3.70%	51.48	51,482,207,000	0.1160
Chile	-	35.32	-	43	0.00%	0.00	-	0.1160
Korea, South	0.20	35.32	7	12	10.60%	0.75	748,678,000	0.1160
Norway	120.60	35.32	4,259	4,375	1.30%	55.37	55,366,857,000	0.1160
Peru	12.80	35.32	452	459	0.10%	0.45	452,032,000	0.1160
Trinidad and Tobago	34.00	35.32	1,201	1,297	3.70%	44.43	44,426,270,000	0.1160

Table D.3 (continued). Propane supply calculations for California sources of imports from rest of world.

Country	Annual Mass of Produced Propane	Density of Propane (liquid)	Annual Volume of Produced Propane (liquid)	Annual Volume of Produced Propane (liquid)	[Conversion]	Annual Volume of Produced Propane (liquid)	Annual Volume of Produced Propane (liquid)
	(lb)	(lb/gal)	(gal)	(m gal)	(bbl/gal)	(bbl)	(bbl/day)
Argentina	5,971,936,012	4.12	24,604,376,369	24,604,376	0.0238	585,830,201	1,605,014
Chile	-	4.12	-	-	0.0238	-	-
Korea, South	86,846,648	4.12	357,808,190	357,808	0.0238	8,519,413	23,341
Norway	6,422,555,412	4.12	26,460,928,297	26,460,928	0.0238	630,034,703	1,726,122
Peru	52,435,712	4.12	216,035,133	216,035	0.0238	5,143,797	14,093
Trinidad and Tobago	5,153,447,320	4.12	21,232,202,958	21,232,203	0.0238	505,538,752	1,385,038

Table D.3 (continued). Propane supply calculations for California sources of imports from rest of world.

Country	Annual Volume of Produced Propane (liquid)	Reference Production (EIA LPG - Non-Refinery - 2014)	Annual Volume of Produced Propane - Based on Reference (liquid)	Reference Consumption (EIA LPG - Non-Refinery - 2014)	If other year for reference data
	(kbbl/day)	(kbbl/day)	(kgal)	(kbbl/day)	
Argentina	1,605	51	781,814	50	CY 2012
Chile	-	0	-	0	
Korea, South	23	23	352,583	248	
Norway	1,726	149	2,284,124	30	CY 2013
Peru	14	46	705,166	44	CY 2013
Trinidad and Tobago	1,385	20	306,594	0.6	CY 2012

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